Pediatric ECMO

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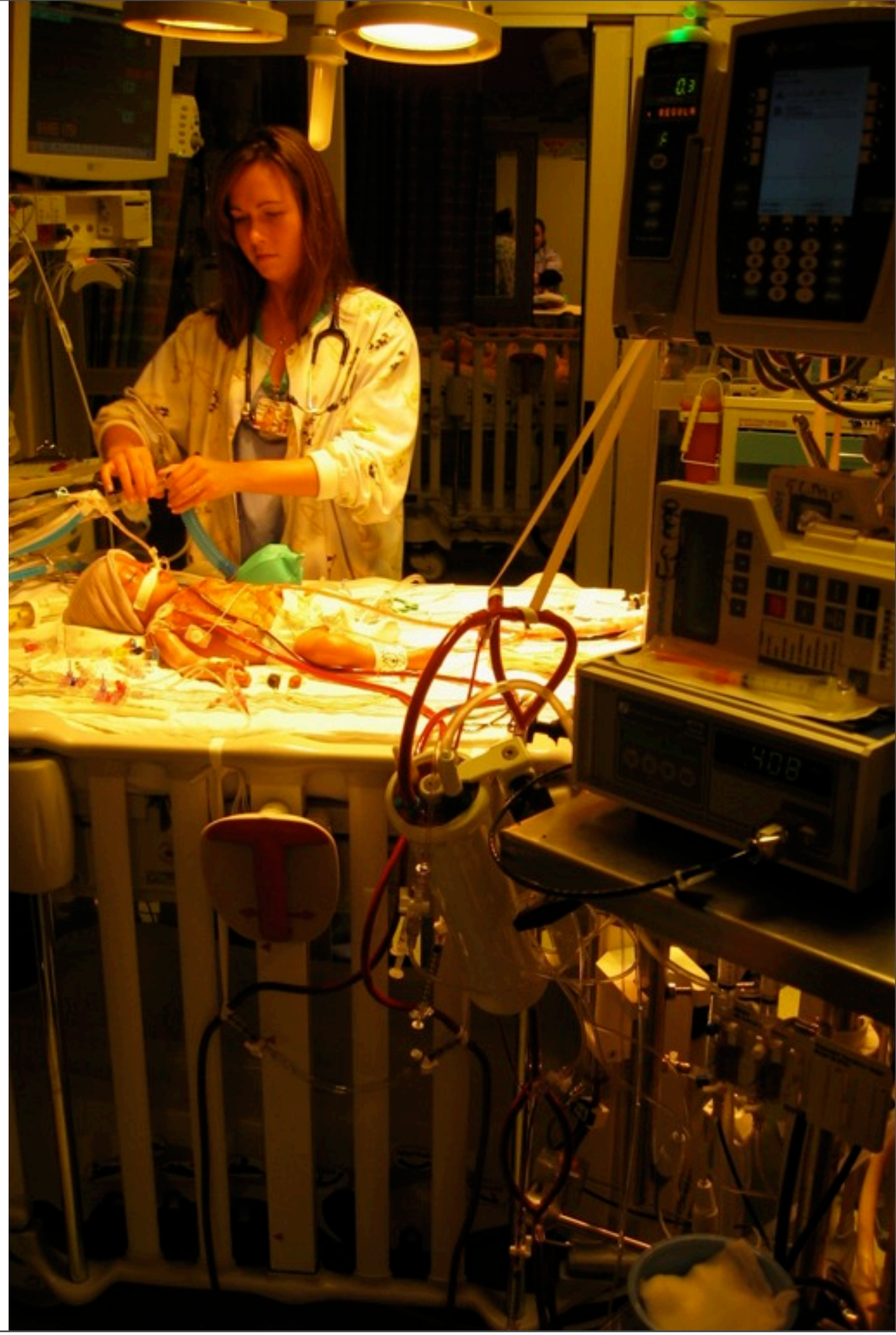

What is ECMO ?

- Extra Corporeal Membrane Oxygenation
- ECLS (Extra Corporeal Life Support)
- Prolonged but temporary support of heart and lung functions using mechanical devices
- Typically used for REVERSIBLE respiratory or cardiovascular failure not responding to conventional treatment
- Many related technologies/ devices/ treatment- ECCO2R, LVAD, RVAD, BiVAD, ECLA, Extracorporeal Pumpless Lung Assist (PECLA)
- Using vascular access, blood is drained, passed/pumped through a gas exchanger (oxygenator) and infused back.

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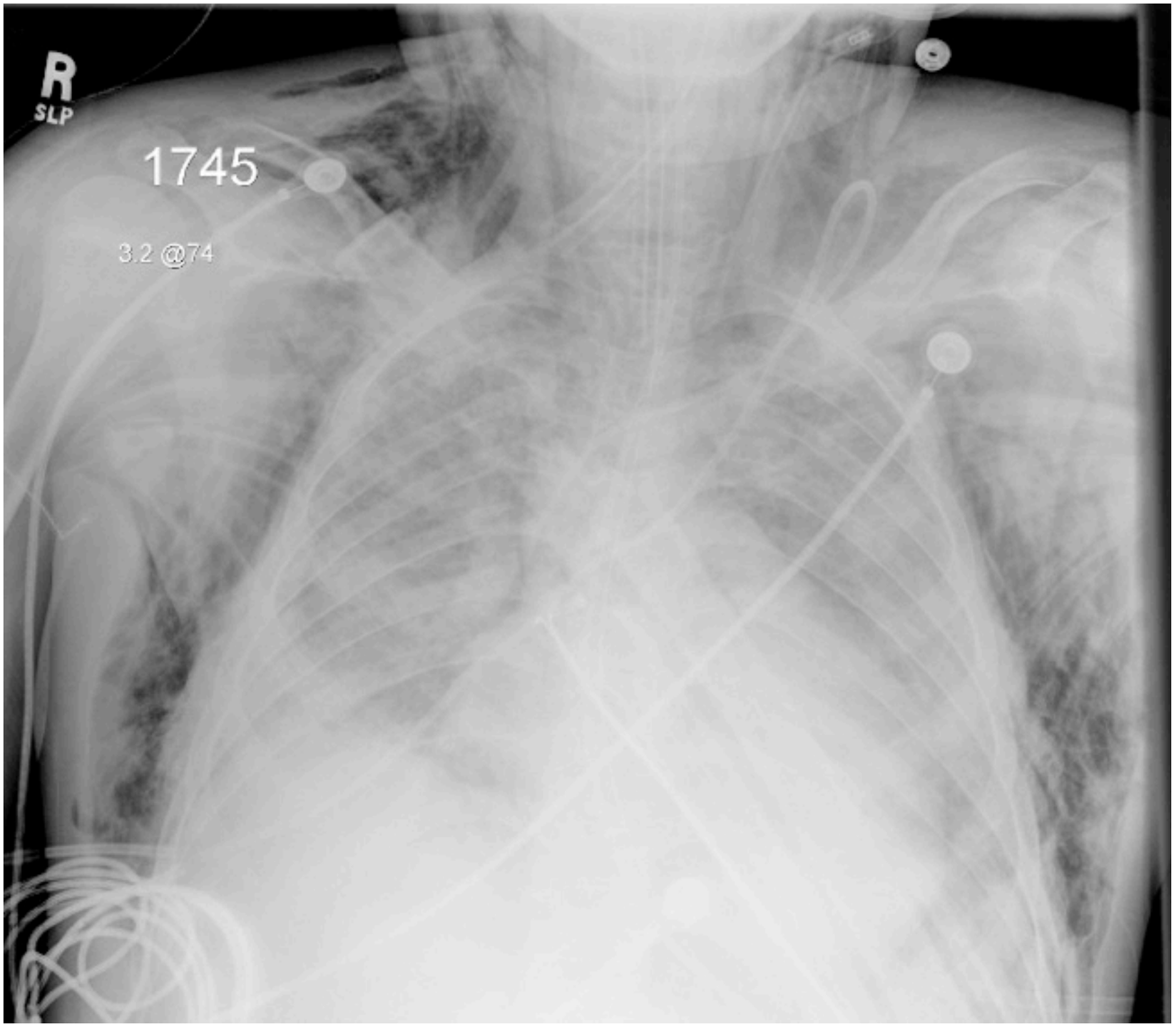
CASE 1



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CASE 2

The Journal of Trauma: Injury, Infection, and Critical Care: 2007; 63 (6) :1380

7-year-old girl sustained a crush injury to her torso when an automobile rolled onto her chest. initially alert and talking; mental status rapidly deteriorated to GCS of 3. Intubated ; now hypotensive

Level1 : SBP 70-90 , hypoxic on 100%, PEEP14 (spO2 86) , Decreased BS rt chest- Chest tube (Tension PTX)- Epi, DA still hypotensive. CT Head/ abd/pelvis/chest -ve.

ECHO- EF 15%, DB added, CK increased, pneumo, SQ emphysema-

VA ECMO- RIJV-RCC, bronch -ve. 24 hr- weaned off pressors, Day 7 LV EF 60%, ECMO weaned, decannulated 143 hrs, extubated

Discharged post-injury day 18, back to school 2 weeks after D/C

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Outline

- Review of Pediatric Respiratory failure
- Concept of Lung rest/ Lung protection
- Neonatal ECMO Vs. Pediatric ECMO
- Indications: ECMO for respiratory failure
- Other indications: Cardiac, ECPR, Sepsis, Metabolic, Warming, Trauma, Burns,airway surgery
- Contraindications
- Outcomes
- Review of evidence

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ARDS & ALI

Acute Lung Injury : Hypoxemic respiratory failure with PaO2 /FiO2 < 300 , Chest XRay findings & Pulm Art wedge(LVEDP) <18 mm. Irrespective of PEEP

ARDS : when PaO2/FiO2 < 200

- Primary : pneumonia, aspiration, inhalation, drowning, contusion
- Secondary: Sepsis, Shock, CPB, TRALI, Hypoxemic arrest, Pancreatitis, Drugs

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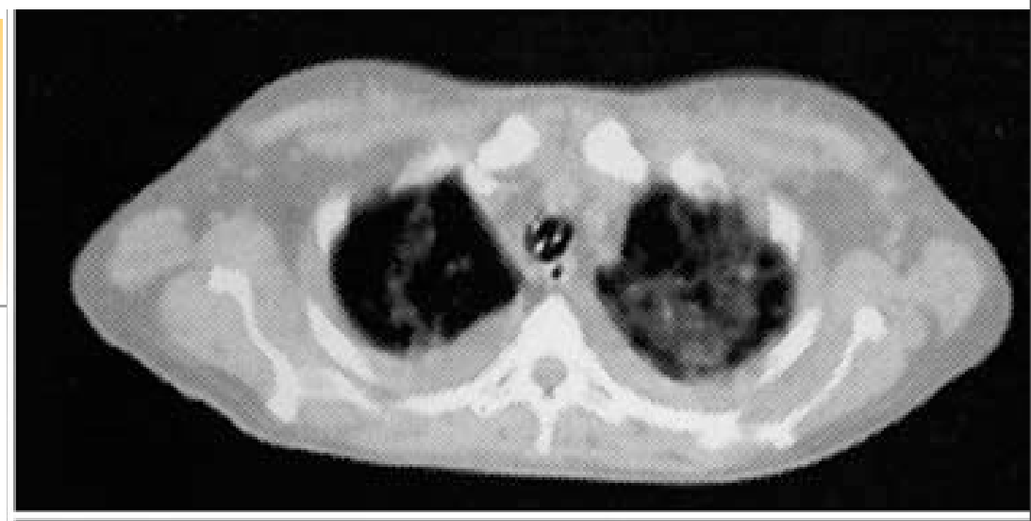
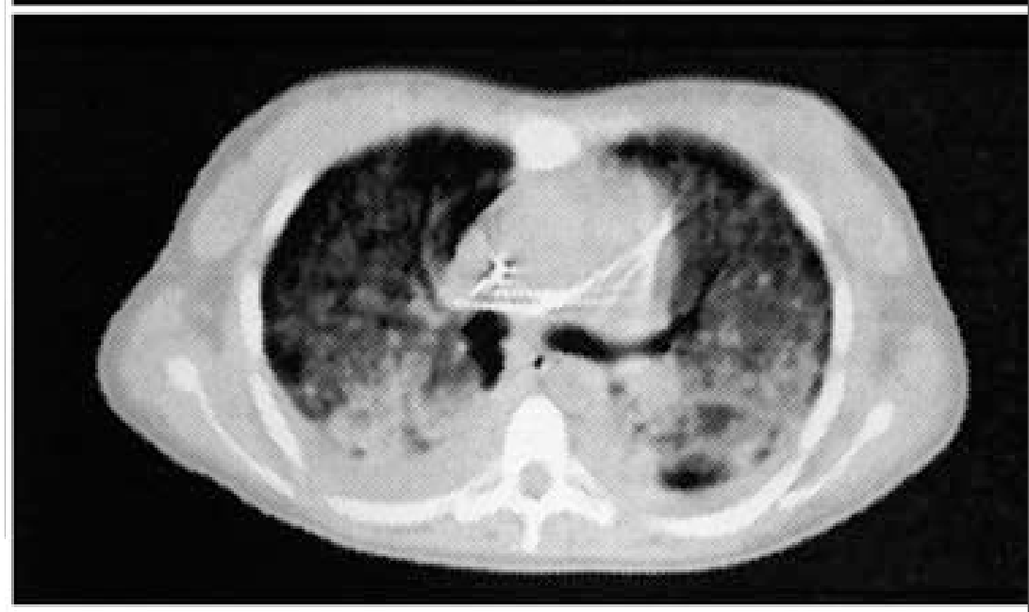
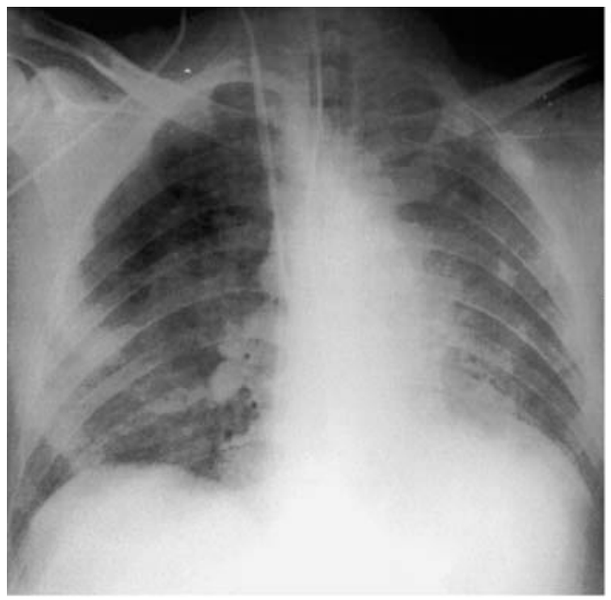
ARDS lungs : Are they stiff ?

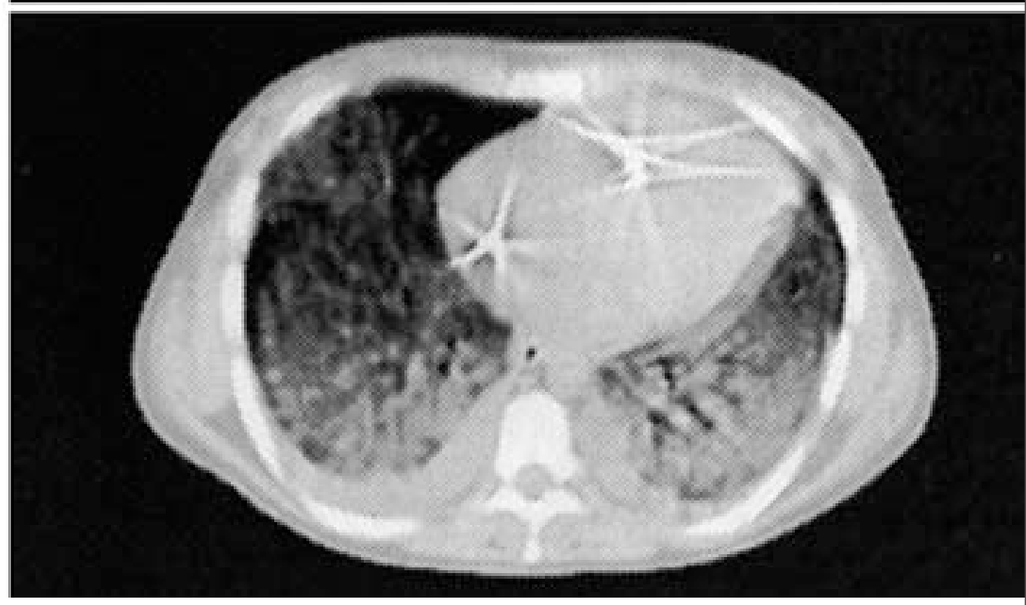
- In 1970s, the ARDS lungs were considered homogeneously “stiff” and heavy. Consequently, one required higher pressures to ventilate these lungs in order to achieve NORMAL PaCO2 & PaO2

- *Gattinoni et al (1987)* showed that ARDS lungs are not uniformly diseased as seen in Anterior-Posterior Plain radiographs, but the are non-homogenous on a Chest CT with increased densities on dependent regions.









Baby Lung rather than Stiff lung

- 3 compartment model : open, collapsed irreversibly, and collapsed but recruitable.

- Uneven distribution of delivered tidal volume : leads to over distention of healthy lung segments

- Treat the ARDS lungs as smaller lung rather than diffusely stiff lung (equivalent of a healthy 5 year old)

- Coined the term “Baby Lung”

Gattinoni et al: Am Rev Respir Dis 136:730-36; 1987

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Ventilator Induced Lung Injury

- Not just barotrauma , but...
- Volutrauma
- Biotrauma
- Atelectotrauma
- Oxygen toxicity
- Mechanical injury
- Infections, cliliary motility

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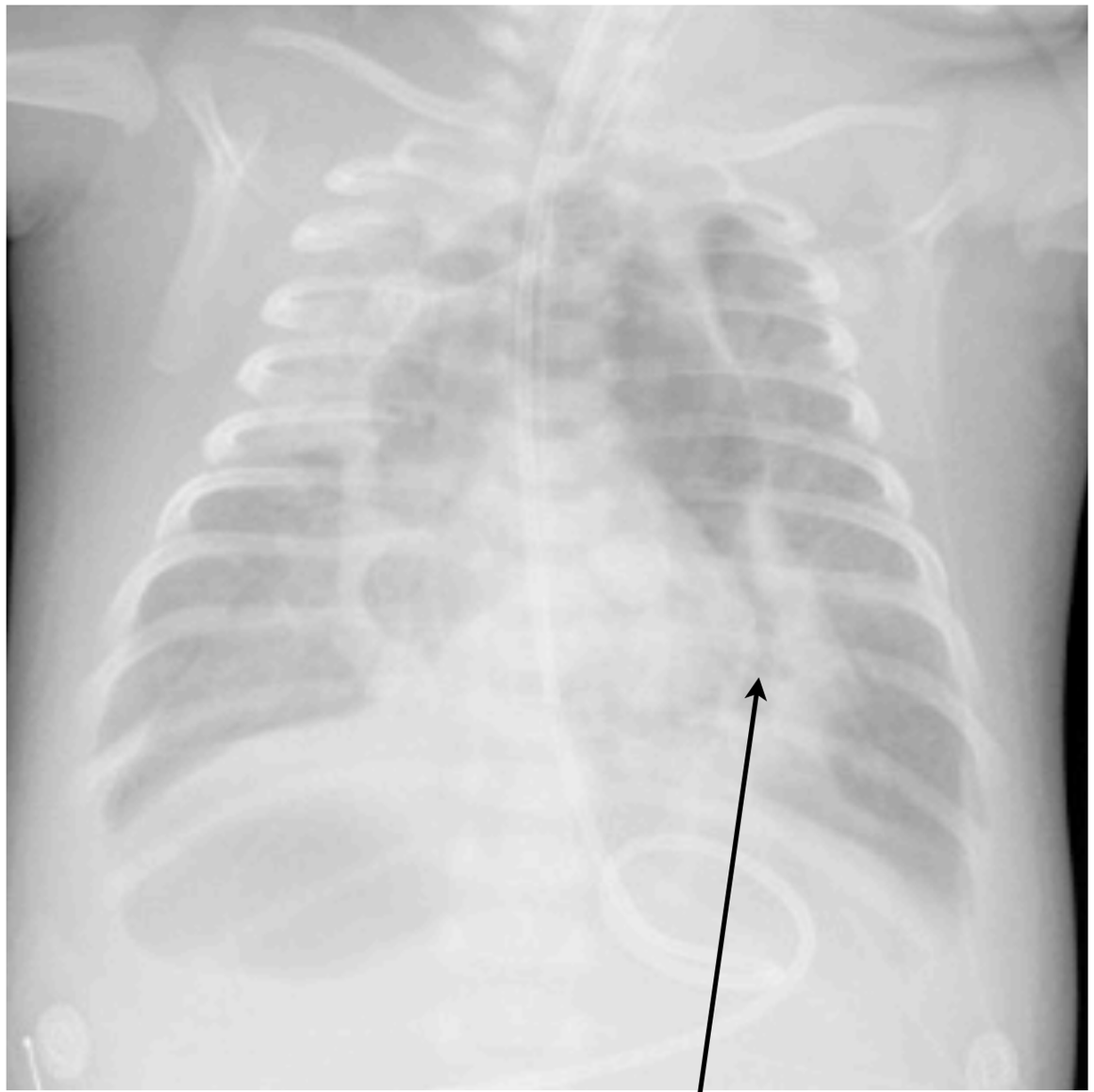
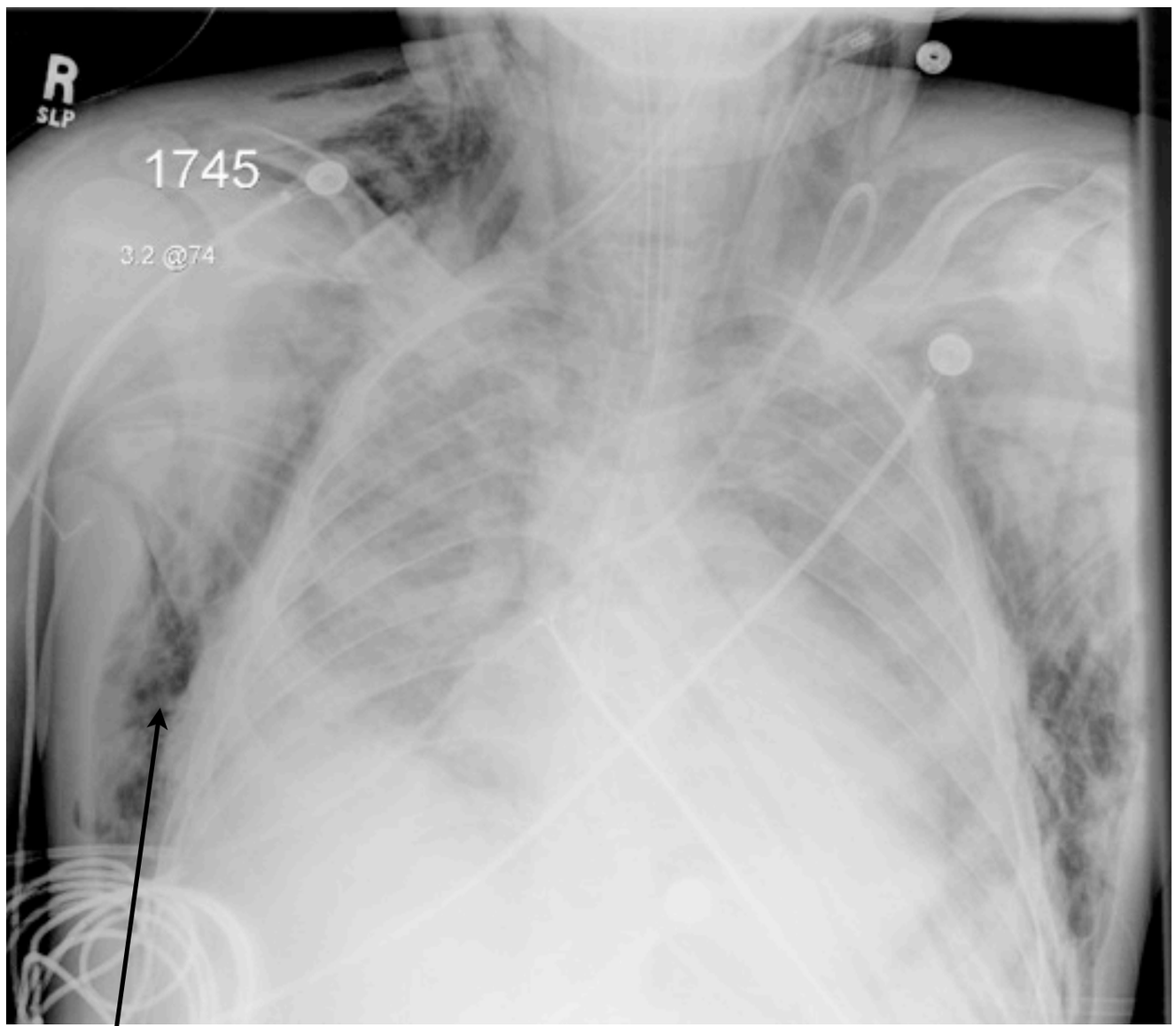
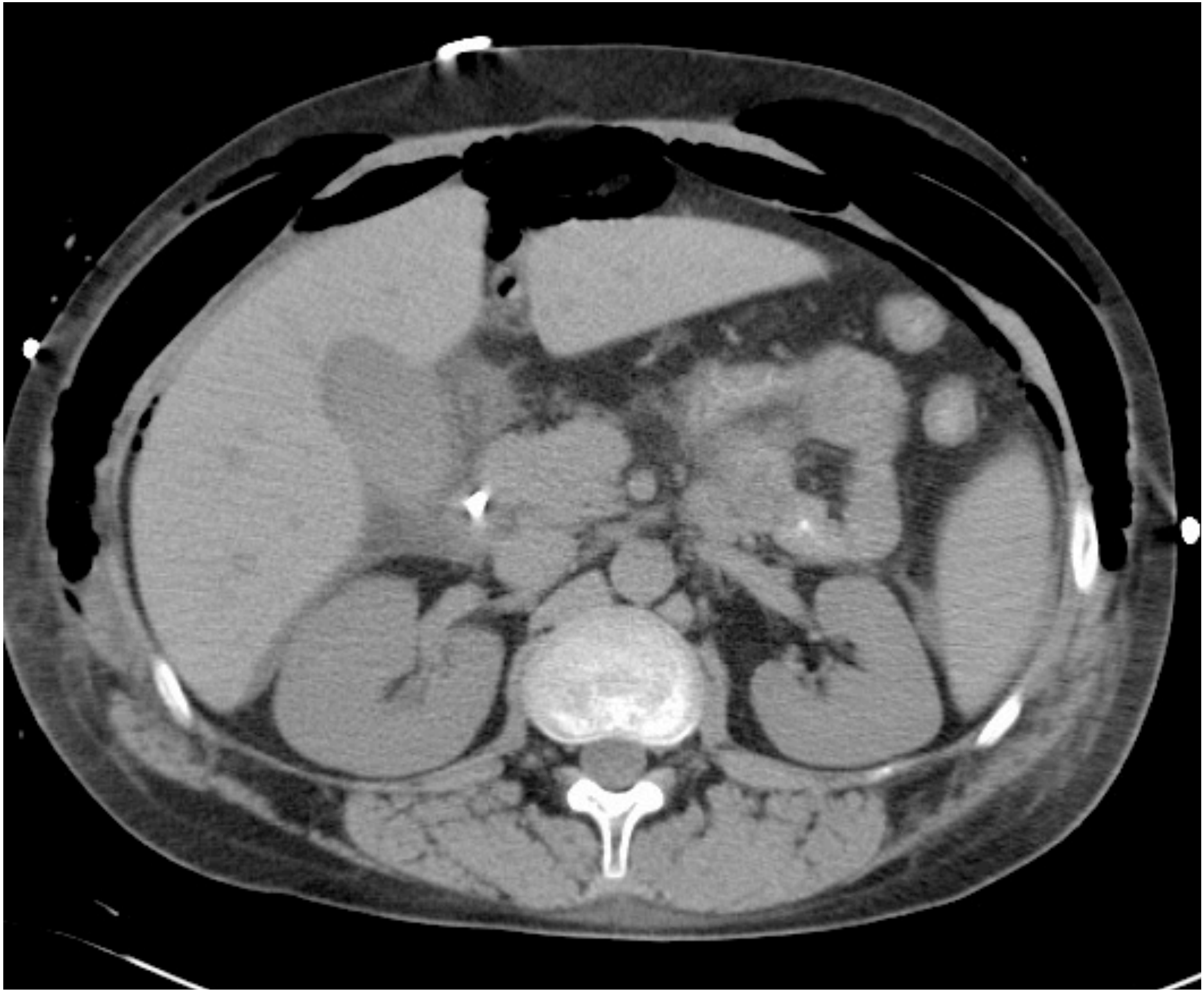
Ventilator-induced Lung Injury





Pneumopericardium

Subcutaneous Emphysema



ARDS: Current Lung Protective Approach

- Tidal Volume 6 ml/kg (ideal body wt)
- PEEP > Lower Inflection Point
- Plateau Pressure < 35 cm
- FiO_2 < 0.6
- RR adjust to keep target pH
- Target pH >7.2 (?), use $NaHCO_3$
- Use Recruitment maneuvers

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Conceptual basis for ECMO

- Many primary & secondary lung injuries make lung ineffective/ unable to perform optimal gas exchange function
- For many years, we tried to “flog the dying horse” to get normal blood gases
- Now we like....kinder, gentler ventilation
- ECMO conceptually offers ideal & ultimate lung protective strategy
- With ECMO, No need to have sub-optimal oxygen delivery, high inspired oxygen related lung toxicity, Barotrauma, Volutrauma, Decrease venous return, VILI...

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Indications

- Severe acute hypoxemic respiratory failure due to reversible cause with poor response to conventional therapies
  - OI >40, Predicted Mortality >80% *(OI= FiO2/PaO2 x MAP x100)*
- Acute reversible hypercapneic respiratory failure with poor response to conv. Rx
- Acute reversible cardiovascular failure with inadequate response to medical management
- Etiology could be varied: infections, trauma, toxins, aspirations, surgical, ALI, arrhythmias, asthma
- Newer indications:

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Cardiovascular Failure

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Contraindications

- Irreversible underlying cause for respiratory or cardiovascular failure
- Any contraindications for systemic anticoagulation, CNS bleed etc.
- Terminal condition

- Relative- ? long course (>7-10 d) of invasive mechanical ventilation
- Severe neurological injury or insult
- ~~Trisomy 21, BMT, Burns, bleeding patient~~

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Veno-Venous vs Veno-Arterial ECMO

Feature	VA	V V
Cannulation site	IJ/RA/FV plus CC,Ax,FA	IJ alone +/-FV, RA
ECMO flow	80-100ml/kg/min	120-150
Typical PaO2	60-150 torr	45-80 torr
Cardiac support	+++	+/-
DO2	High	Moderate
Recirculation	-	+
Systemic embolization	High Risk	Low Risk
Flow pattern	Non-pulsatile	Pulsatile
Cannulation	Open	Open/ PerQ

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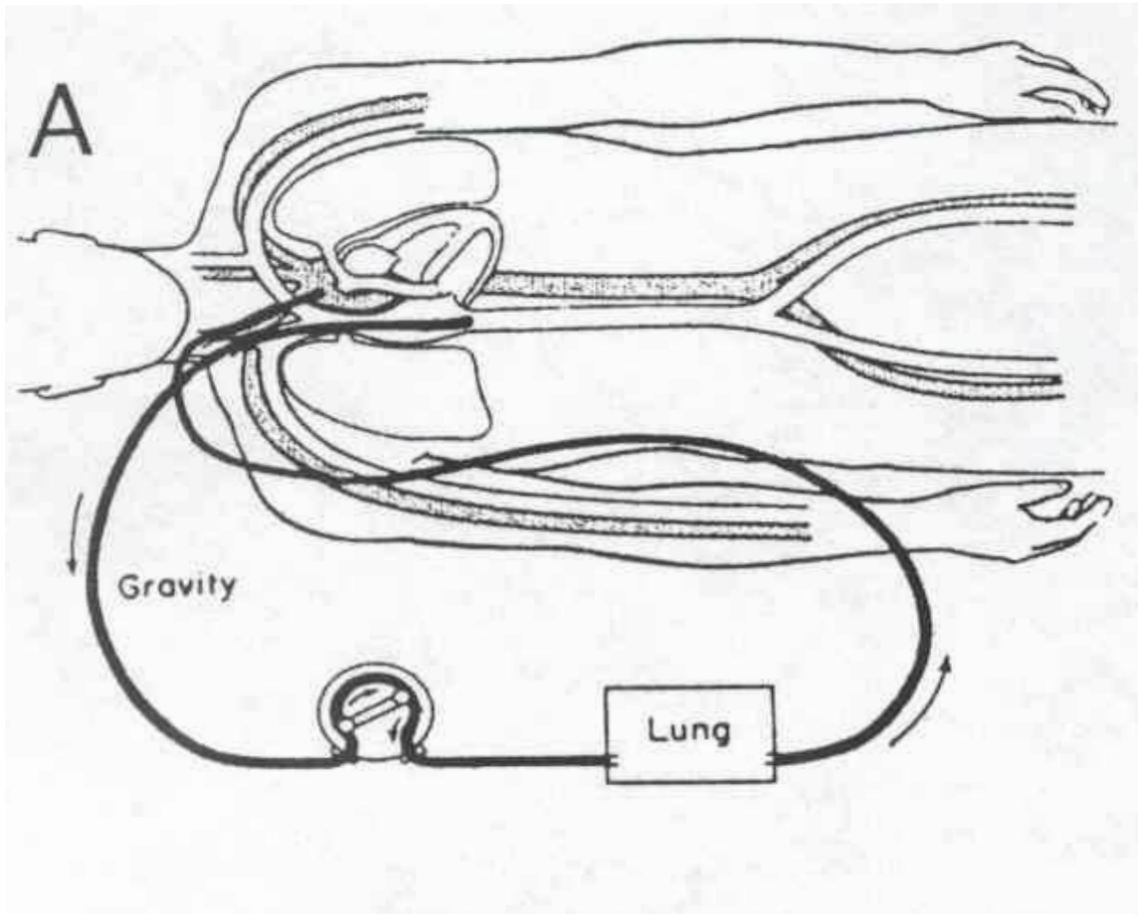

Cannula Configurations

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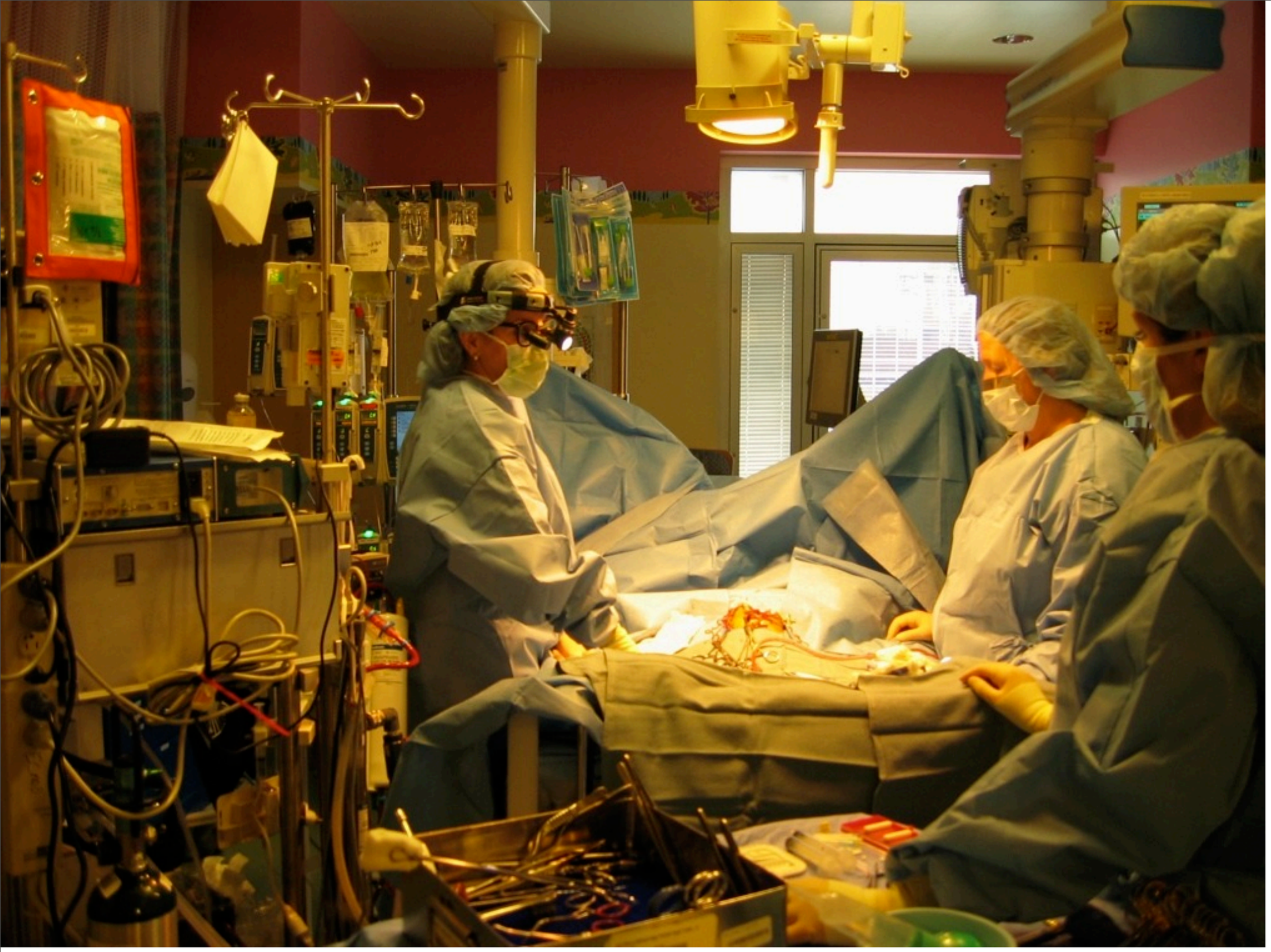

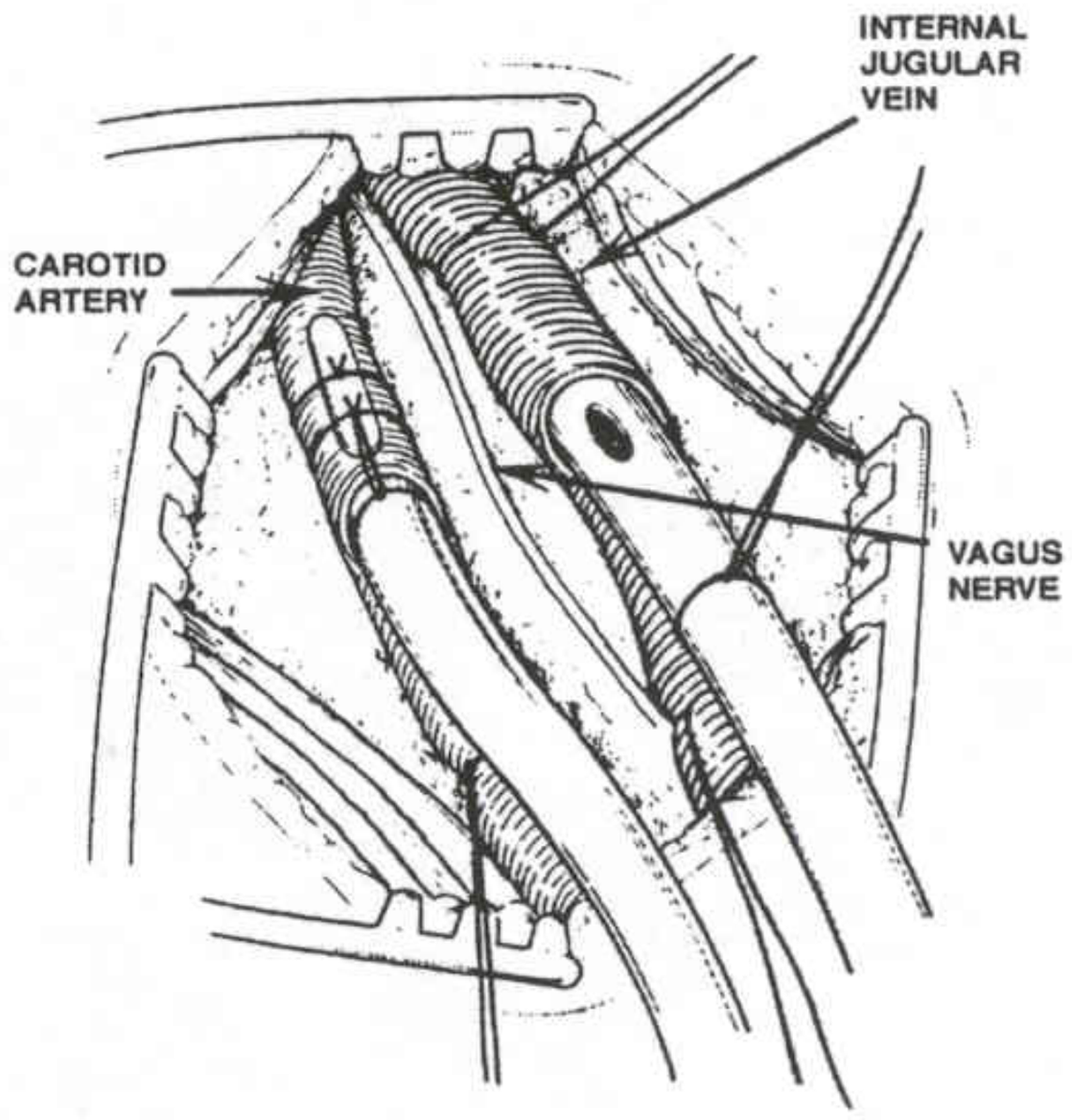

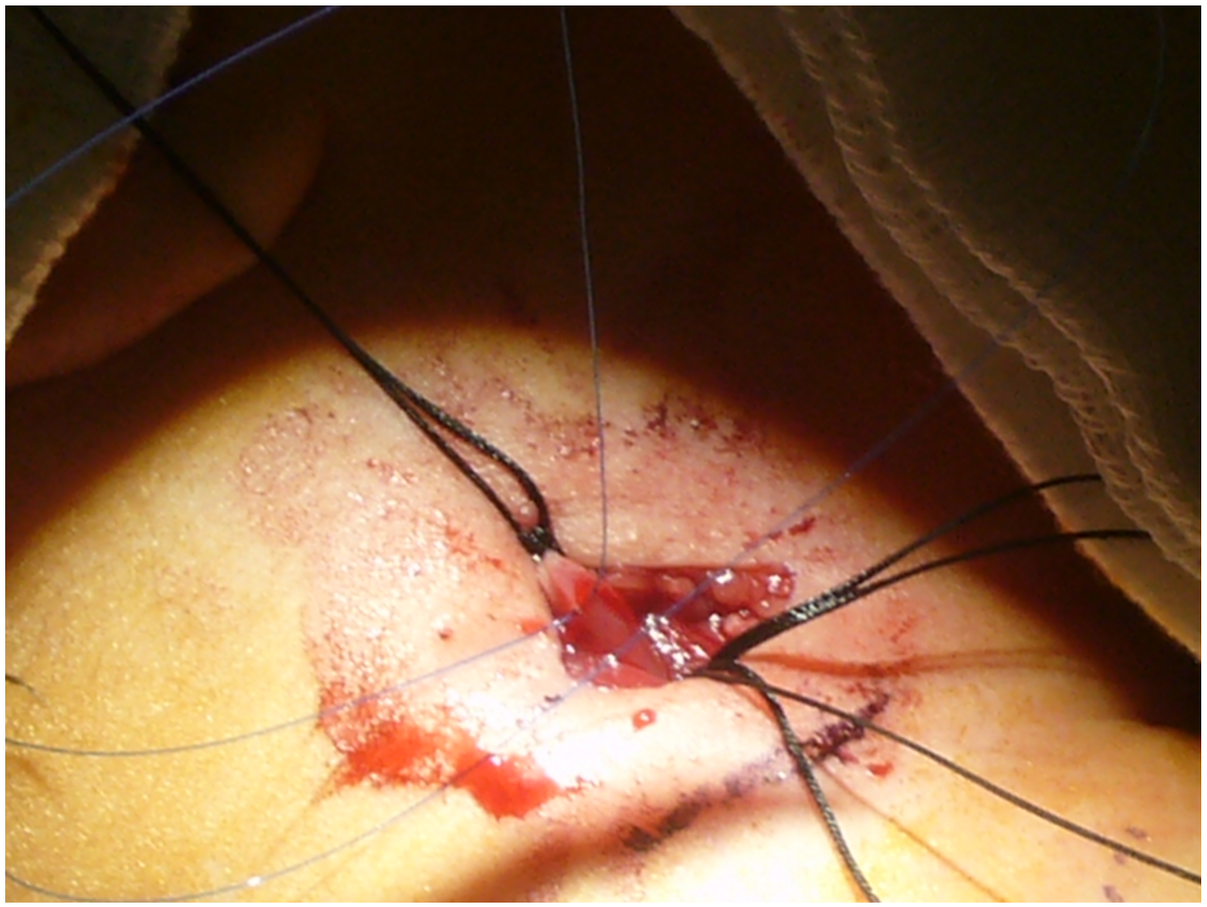

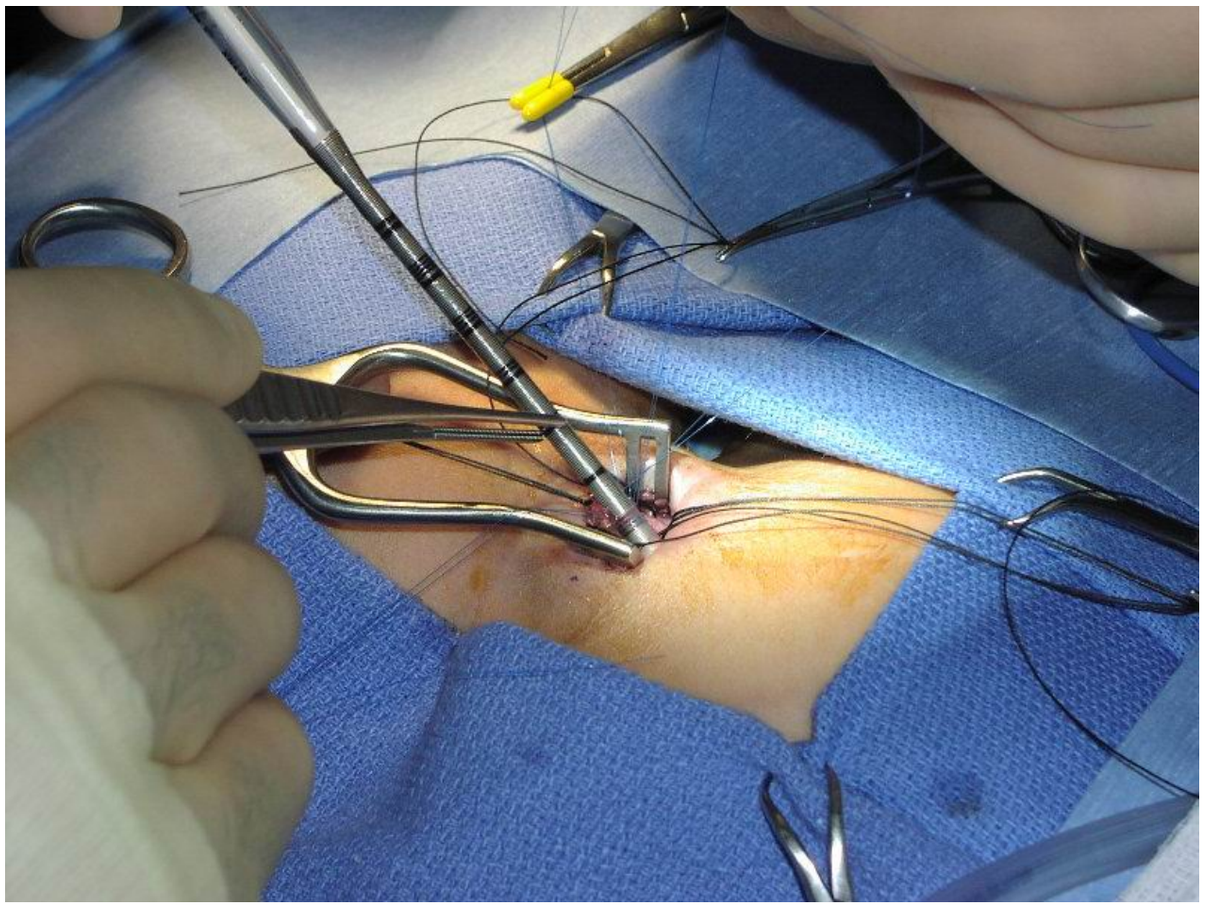

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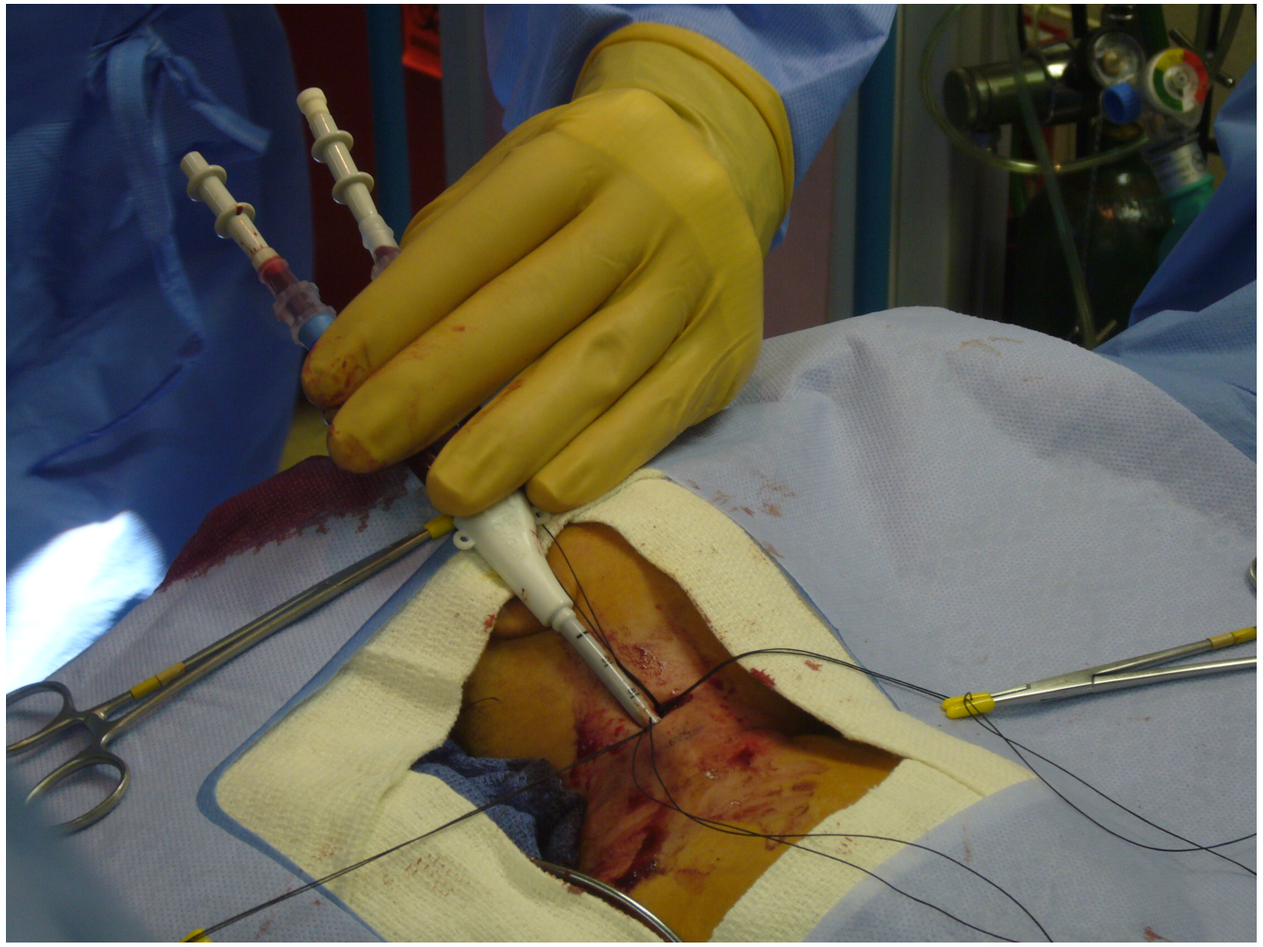

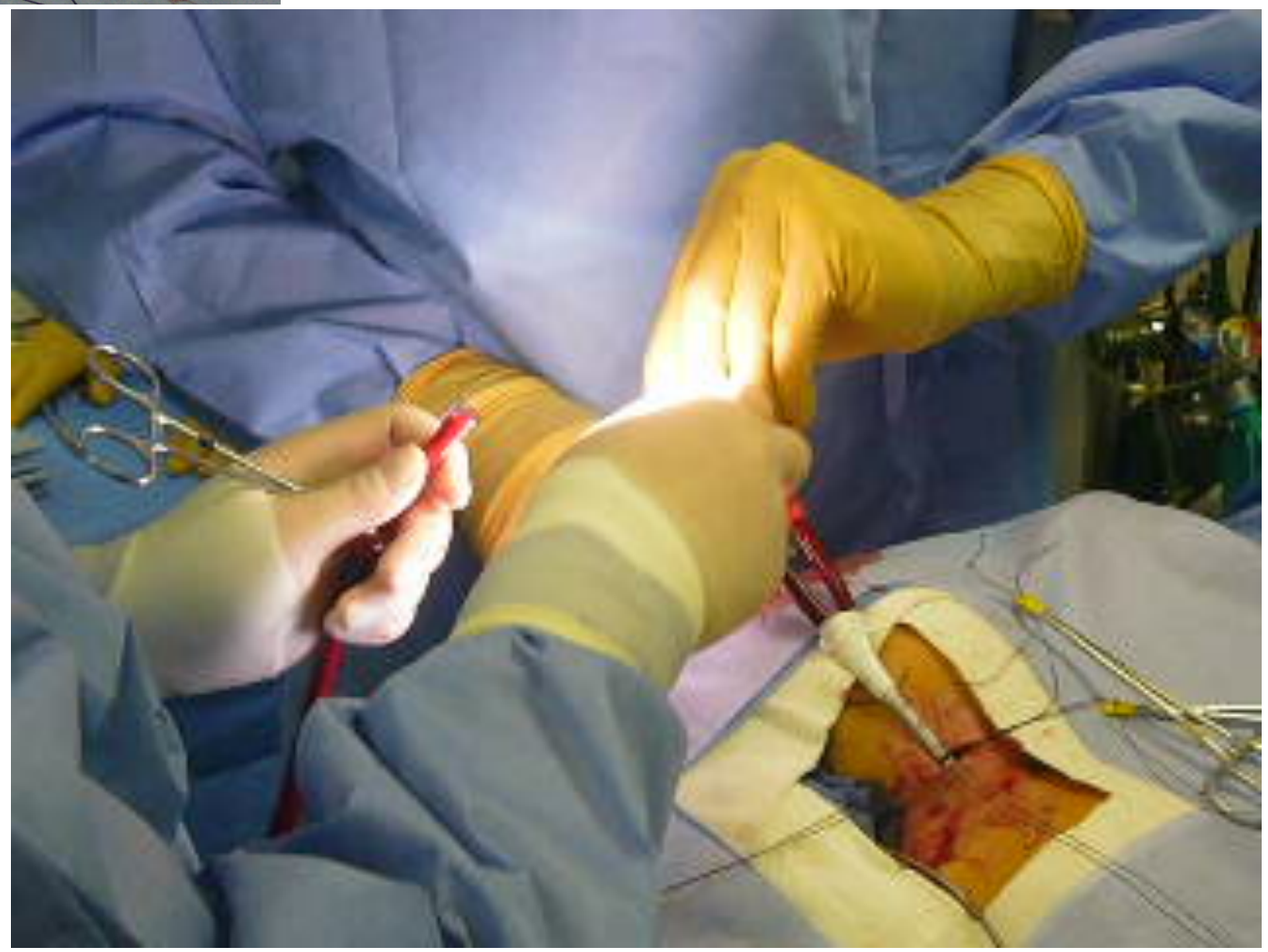

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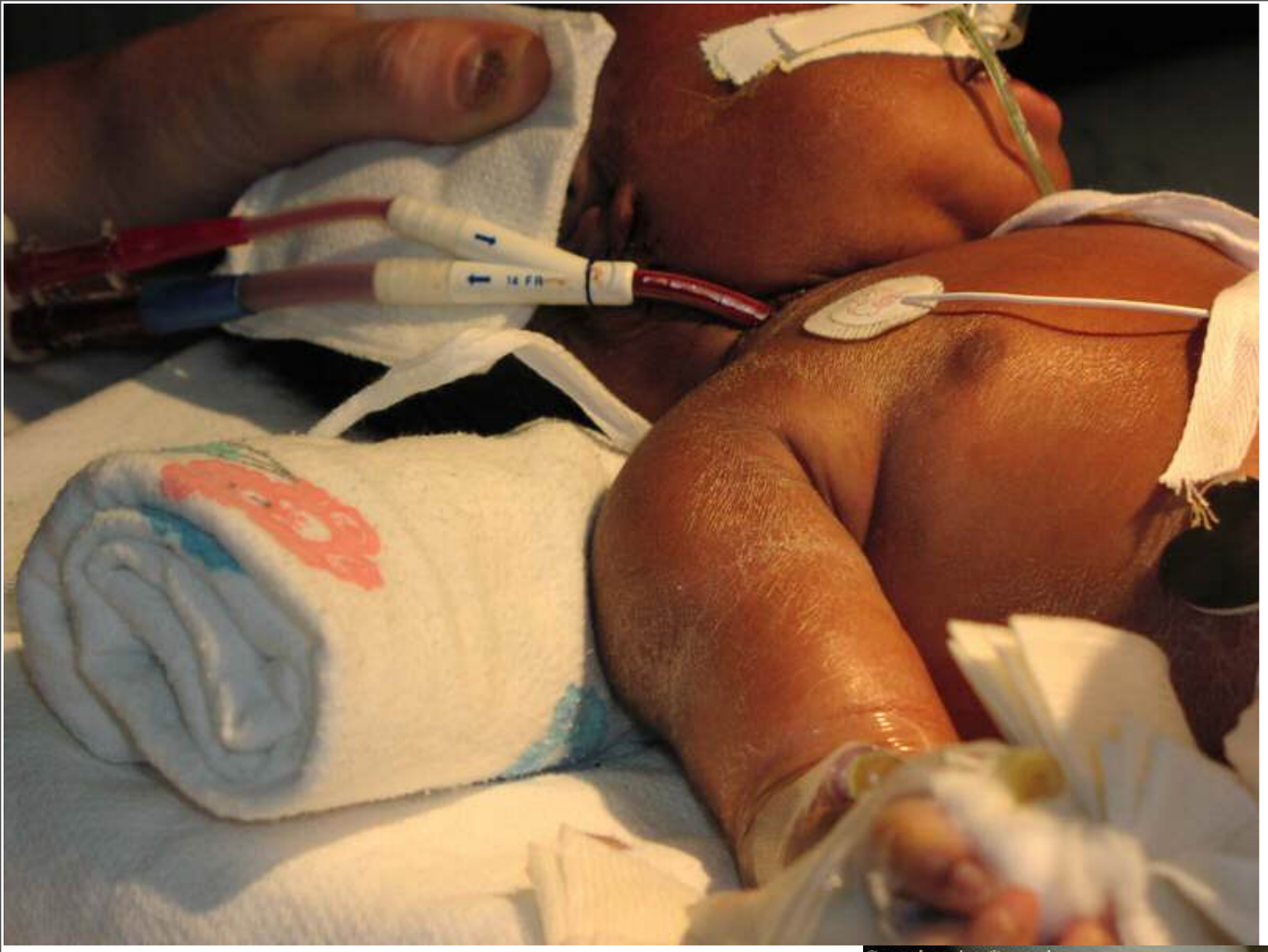

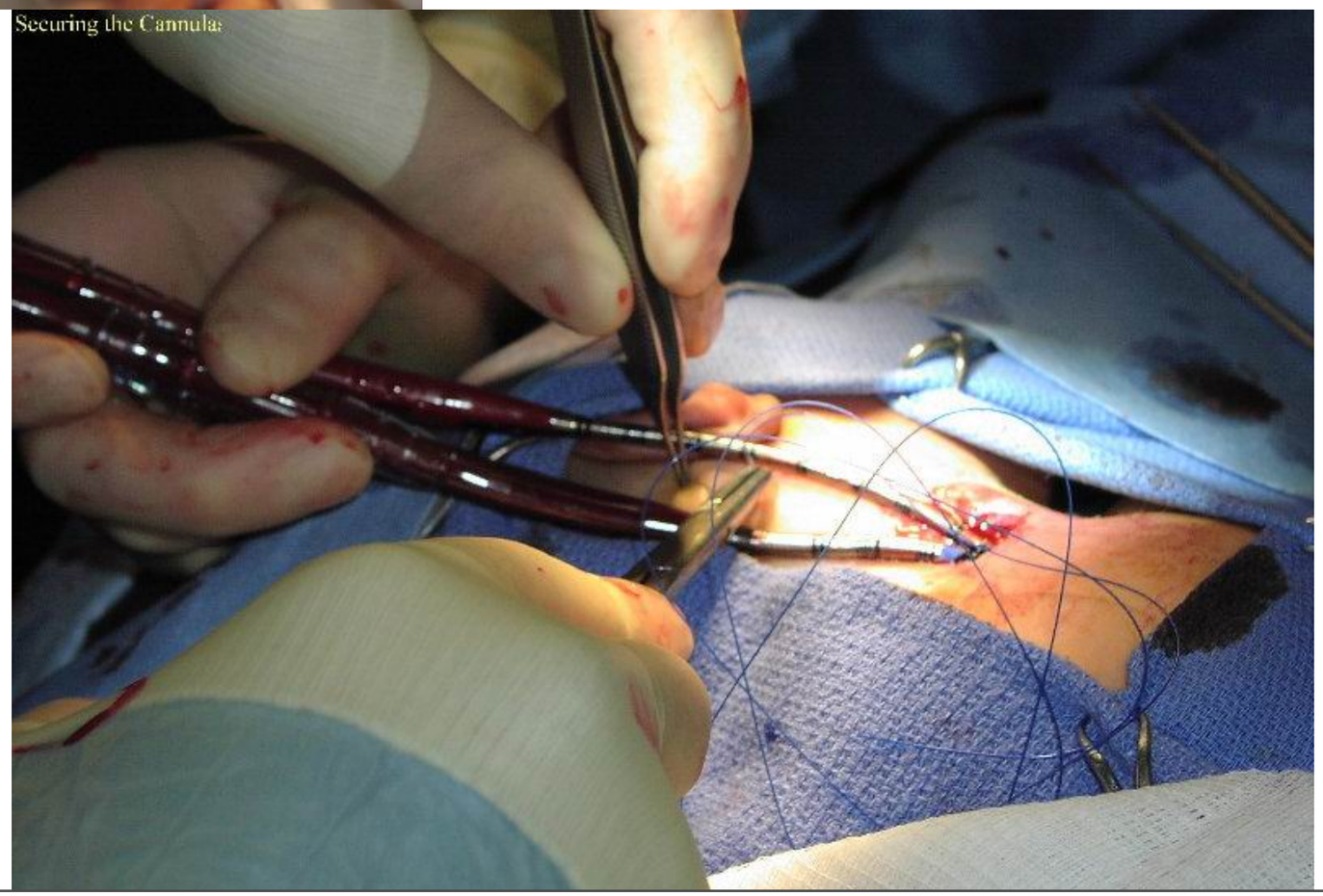

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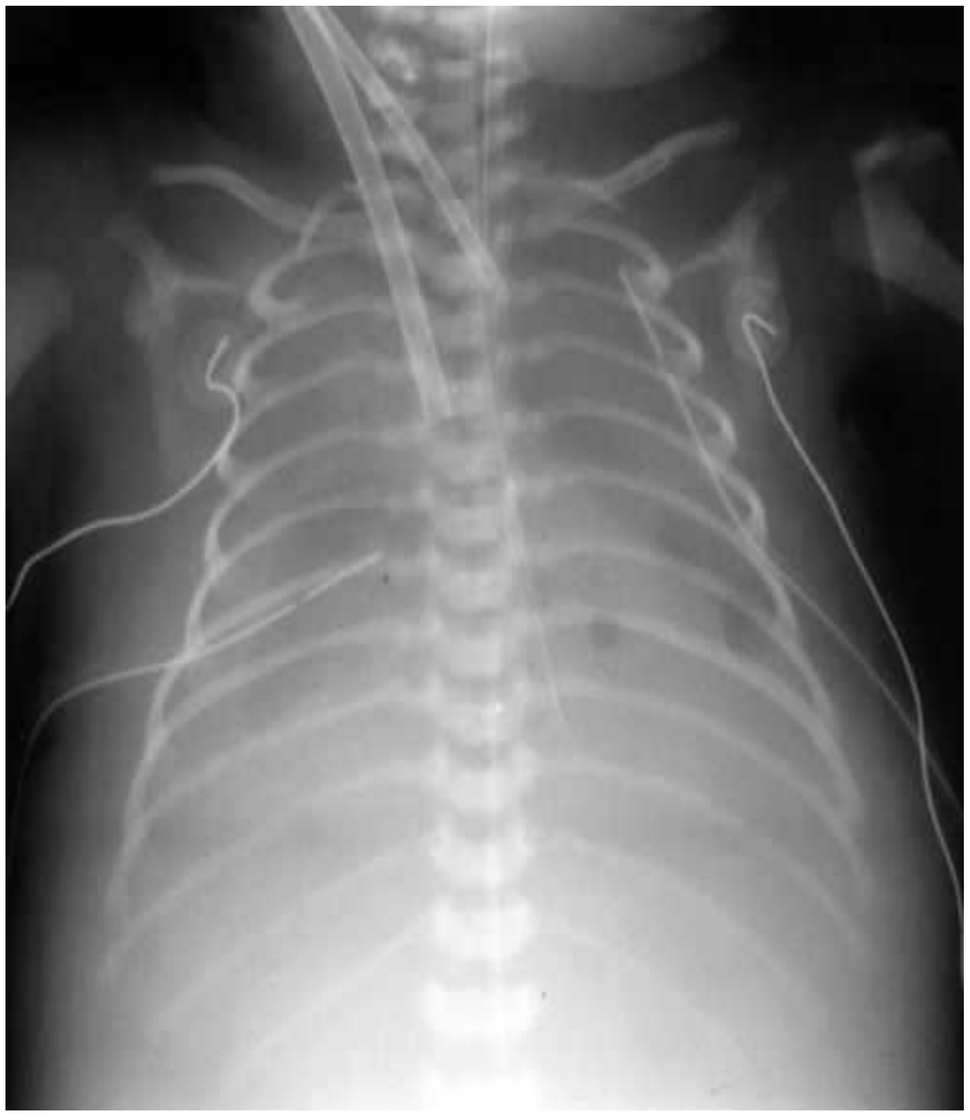

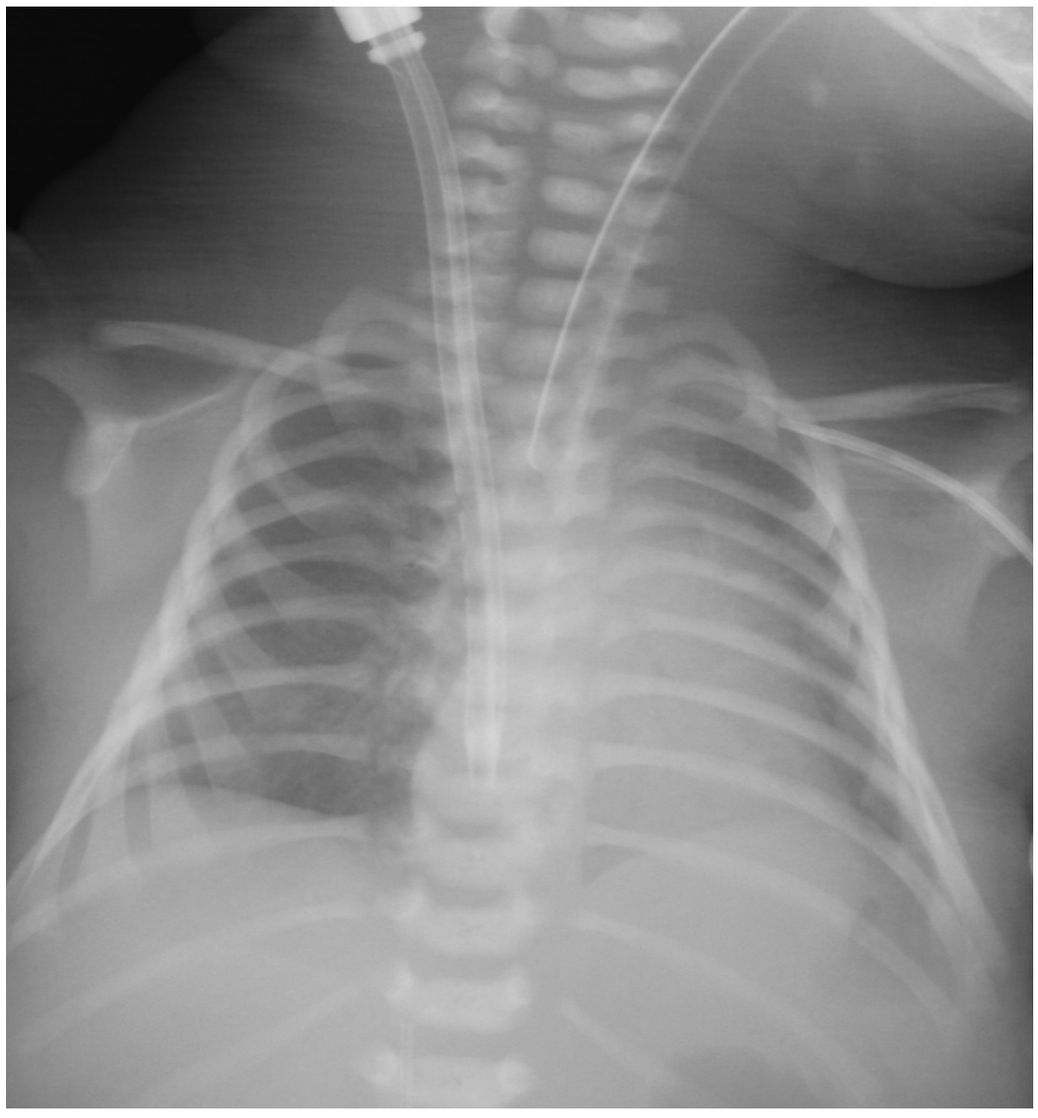

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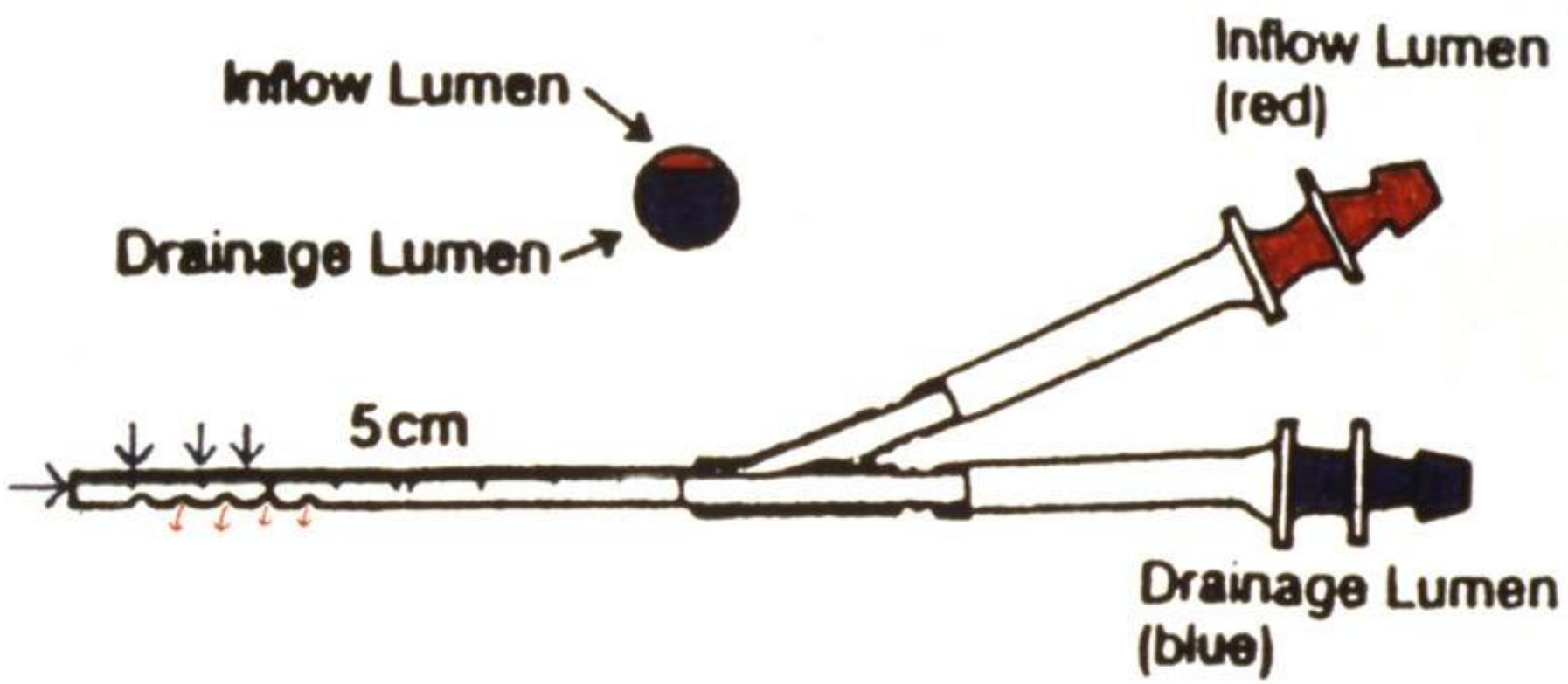
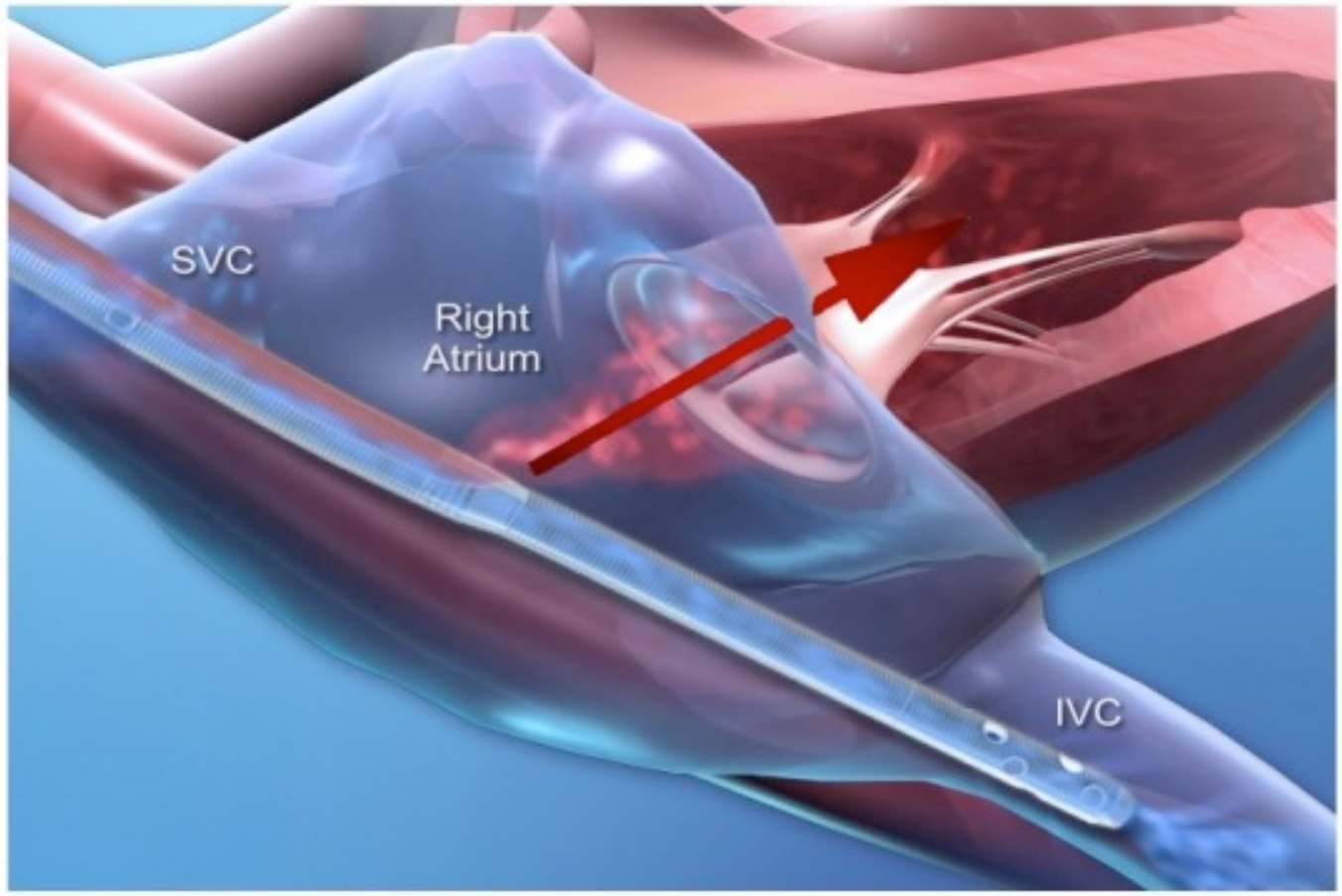

Inflow Lumen
Drainage Lumen
5cm
Inflow Lumen
(red)
Drainage Lumen
(blue)


SVC
Right
Atrium
IVC

CASE

J Pediatr Surg 38:1221-1226. 2003

4 year old Passenger in MVA, intubated at scene- Rt frontal Contusion on CT scan. ICP monitor placed, dc'd 48 hrs. Needed lap for jejunal perforation on day 3.

Developed septic shock, ARDS day 4. OI 55 P/F 56, HFOV- air leaks, B/L Chest tubes. ECMO VV initiated Day 5. RIJV-RFV, Cephalad RIJ Catheter as well

Bleeding from surgical sites, wounds. Amicar started, Aprotonin started- improvement after 72 hrs.

Developed Anuric Renal failure, started CVVH. Circuit changed Days 9 & 17. Broch x2 for plugs

Weaned of ECMO day 29, extubated Day 34. Neurological/ respiartory OK on Follow-up

ECMO in trauma ? (indications)

- ARDS (SIRS related)
- Fat/pulmonary embolism (long bones/ pelvic fractures)
- Pulmonary Contusion (direct lung injury)
- Tracheo-bronchiolar injury
- Smoke Inhalation
- Major burns, esp. to torso
- Myocardial Contusion

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Acute respiratory distress syndrome is as important as inhalation injury for the development of respiratory dysfunction in major burns☆

Ingrid Steinvall [a,c,*], *Zoltan Bak* [a,b], *Folke Sjoberg* [a,b,c]

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BURNS 34 (2008) 441–451

Pediatric Burn Patients With Respiratory Failure: Predictors of Outcome With the Use of Extracorporeal Life Support

Timothy D. Kane, MD,[a] David G. Greenhalgh, MD,[b] Glenn D. Warden, MD,[b]
Michael J. Goretsky, MD,[a] Frederick C. Ryckman, MD,[a] and Brad W. Warner, MD[a]
Cincinnati, Ohio

Extracorporeal life support (ECLS) for pediatric burn patients is a viable option for respiratory failure that is unresponsive to maximal conventional therapy. No criteria have been identified that are predictive of the success of the use of ECLS for these patients. This article presents a retrospective review of the pediatric burn patients placed on ECLS at a single pediatric medical center. It was found that 12 patients (mean age, 30.3 months; range 6 to 69 months) were placed on ECLS because of profound pulmonary failure that was unresponsive to aggressive ventilatory support. The mean size of the burns of these patients was 50.2% of the total body surface area (average size of full-thickness burns, 41.8% total body surface area), with 6 patients having scald burns and 6 having flame burns. The overall survival was 67% (8 of 12). Nonsurvivors had greater positive end-expiratory pressure, mean airway pressure, peak inspiratory pressure, and oxygenation index before ECLS. It is felt that ECLS is a life-saving therapy for pediatric patients with thermal injury. Greater ventilator requirements before ECLS are associated with nonsurvival. Early institution of ECLS in pediatric burn patients with severe respiratory failure may prevent excessive barotrauma and thus discourage the onset of irreversible lung injury. (J Burn Care Rehabil 1999;20:145-50)

Traumatic lung injury treated by extracorporeal membrane oxygenation (ECMO)

J.A. Cordell-Smith [a,b,*], N. Roberts [a,c], G.J. Peek [a], R.K. Firmin [a]

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[c] *Northern General Hospital, Herries Road, Sheffield S5 7AU, UK*

Methods: Retrospective analysis over an 8-year period of all 28 adult patients referred to a single tertiary unit for ECMO support. Survival relative to Injury severity score (ISS), lung injury score (Murray grade), duration of treatment and patient age was evaluated.

Results: Twenty of 28 patients who received ECMO with severe trauma related respiratory failure (mean PaO_2/FiO_2 of 62 mmHg) survived. Most patients had long bone fractures, blunt chest trauma, or combined injuries. Lung injury and injury severity scores, patient age, ECMO duration and oxygenation indices pre-ECMO (PaO_2/FiO_2) were similar in both the survivor and non-survivor groups.

Conclusion: A high proportion of trauma patients treated with ECMO for severe lung injury survived. This outcome appears to compare favourably to conventional ventilation techniques and may have a role in patients who develop acute severe respiratory distress associated with trauma.

Michigan Experience in Adults

Michaels, Andrew J. MD, MPH; Schriener, Robert J. MD; Kolla, Srinivas MD; Awad, Samir S. MD; Rich, Preston B. MD; Reickert, Craig MD; Younger, John MD; Hirschl, Ronald B. MD; Bartlett, Robert H. MD

The Journal of Trauma: Injury, Infection, and Critical Care 46(4), April 1999,

- 30 adults (>15yr) from 1989-97, with risk of mortality >80%
- 83% blunt trauma
- 56% weaned off, 50% discharged home
- Renal failure and VA support more common in non-survivors
- All were heparinized: 58% Bleeding complication (Reqd Intervention)- not causative of mortality
- 63% underwent operative procedures during ECLS
- Early ECLS (<5 d MV) associated with improved survival

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Extracorporeal Life Support for Posttraumatic Acute Respiratory Distress Syndrome at a Children's Medical Center

By James D. Fortenberry, Andreas H. Meier, Robert Pettignano, Michael Heard, C. Robert Chambliss, and Mark Wulkan

Atlanta, Georgia and Orlando, Florida

Methods: ECMO Center records from 1991 through 2001 (76 children, 8 adults) were reviewed to identify all patients with a primary or secondary ICD-9 diagnostic code of posttraumatic ARDS in addition to documented trauma.

Results: Five children and 3 adults with traumatic injury and ARDS received ECMO support. Seven patients were injured in motor vehicle collisions; one patient suffered a gunshot wound to the chest. Patient ages ranged from 21 months to 29 years (pediatric median, 4 years; range, 21 months to 18 years). Four patients had pre-ECMO laparotomies, including 3 who required splenectomy. Four patients had liver lacerations, 3 had pulmonary contusions, and 1 had a renal contusion. Median ventilation before ECMO was 6 days (range, 2 to 10). Seven of 8 patients were placed on venovenous (VV) ECMO. Seven patients had significant bleeding on ECMO. Patients were treated with blood product replacement, epsilon-aminocaproic acid (EACA), and aprotinin infusions. Surgical intervention was not required for bleeding. Six patients received hemofiltration. Median time on ECMO was 653 hours (range, 190 to 921 hours). Six of 8 patients overall survived (75%). Four of 5 pediatric patients survived.

Conclusions: Children and adults with severe posttraumatic ARDS can be treated successfully on VV extracorporeal support. Hemorrhage occurs frequently but is manageable.

J Pediatr Surg 38:1221-1226.

Atlanta Children's Experience (5 children+ 3 Adults)

- Median age 12.5 years (4 yrs for the children)
- Pre-ECMO ventilator days : 6
- 4/5 children- VV ECMO
- 7/8 had additional cephalad cannula
- Median ECMO run : 12 days (18 d in children)
- 5/8 required CVVH

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Atlanta Children's Experience (5 children+ 3 Adults)

- Significant bleeding in 7/8- EACA used routinely
- Mechanism : MVA 7, GSW 1
- Liver Laceration : 4
- Splenic Laceration : 4
- Lung contusion : 3
- Kidney contusion : 1
- CNS contusion : 2
- SDH (minor) : 1
- Pneumothorax : 2
- Multiple femoral/pelvic fractures: 1
- Pre-ECMO lapratomies : 5
- ICP monitor : 1

75% SURVIVAL to DISCHARGE

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Unproven rescue therapies

- Tracheal Gas Insufflation
- Permissive hypercapnia
- Inhaled Nitric Oxide
- High PEEP
- Recruitment Maneuvers
- High Frequency Oscillatory Ventilation
- Prone positioning
- Corticosteroids
- APRV
- Surfactant
- Inhaled Prostacyclin

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Neonatal ECMO- Evolution

- 1976 : Bartlett case report Esperanza *(Trans Am Soc Artif Intern Organs 1976: 22:80)*
- 1982 : Series of 45 newborns (MAS, PPHN, CDH) *(Surgery 1982; 92: 425)*
- 1989 : O'Rourke RCT in PPHN *(Pediatrics, 1989; 84:957)*
- 1996: UK Collaborative ECMO Trial - 185 babies, 1-year survival 59% survival vs 32% in controls, p=0.0005. No increase in CNS disability. Cost-effective *(Lancet 1996; 348:75)*
- 2000- iNO use leads to significant reduction in need for ECMO for PPHN & MAS. *(Pediatrics 2000; 106: 1339)*

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Pediatric ECMO- evidence

- All case series- single institution
- ELSO database

Journal of Pediatric Surgery
www.elsevier.com/locate/jpedsurg

Factors associated with survival in pediatric extracorporeal membrane oxygenation—a single-center experience

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10 yr, 58 children, 57% decannulated, 48% discharged. OI < 35 & pH >7.2 associated with survival, Mean 5.9 days

Key words:
ECMO;
Pediatric;
pH;
Oxygenation index;
Survival

Abstract

Aim: We aimed to examine outcomes of extracorporeal membrane oxygenation (ECMO) therapy in the pediatric population and identify pre-ECMO and on-ECMO characteristics that are associated with survival.

Methods: We retrospectively reviewed the ECMO records at our institution between 1999 and 2008 and selected pediatric patients who were cannulated for respiratory failure or hemodynamic instability resistant to conventional interventions. We recorded details of pre-ECMO clinical characteristics, including blood gas variables and mechanical ventilatory support, and details of ECMO therapy including survival off ECMO and to hospital discharge. Predictors of survival were analyzed using logistic regression modeling and a prediction algorithm was developed.

Results: Of the 445 ECMO runs, data from 58 consecutive patients were analyzed: 57% were successfully decannulated, and 48% survived to discharge from the hospital. The cohort included 32 (55%) female patients, 22 postoperative patients (38%), and 15 (26%) with an immunosuppressive condition, with a median age of 5 years and weight 19.5 kg, The mean duration of pre-ECMO respiratory support was 3 days, in the form of high-frequency oscillatory ventilation (n = 28, 48%) and conventional mechanical ventilation (n = 13, 22%). The median duration (interquartile range) of ECMO support was 142 hours (60, 321) or 5.9 days. Pre-ECMO pH above 7.2 ($P < .001$) and oxygenation index below 35 ($P = .021$) were associated with the highest survival rates. Pre-ECMO $PaCO_2$ and duration of mechanical ventilation were not associated with survival.

Conclusions: Based on our results, ECMO therapy should be considered early in children with oxygenation index greater than 35 with worsening metabolic status. The restriction of ECMO based on ventilator days alone needs to be revisited in this era of lung protective ventilation.

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Journal of Pediatric Surgery

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Effect of preextracorporeal membrane oxygenation ventilation days and age on extracorporeal membrane oxygenation survival in critically ill children ☆

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Key words:
ECMO;
Survival;
Ventilation;
Risk;
Pediatric

Abstract

Purpose: The aim of the study is to test the effect of age and preextracorporeal membrane oxygenation (pre-ECMO) days of ventilation on ECMO survival in the pediatric population.

Methods: Retrospective analysis of noncardiac, pediatric (age >30 days) ECMO patients for the period January 1984 to June 2006. Pre-ECMO demographic, ventilatory, and lung injury severity variables were modeled with stepwise logistic regression to estimate survival probabilities associated with pre-ECMO ventilation duration and patient age. Patients were excluded from review for the following: pre-ECMO cardiac arrest, pre-ECMO ventilation of more than 30 days (chronic), or multiple runs on ECMO.

Results: For the period of review, 2550 patients met inclusion/exclusion criteria. The population had a mean age of 3.6 ± 5.1 years (median age, 1 year). The mean pre-ECMO days of ventilation were 5.2 ± 4.9 (median, 4 days). The overall survival probability was 58.6%. The mean oxygen index and Pao_2/Fio_2 ratio were 62.2 ± 48.2 and 95.5 ± 48.2, respectively. The population overall demonstrated a statistically significant, exponential decline in survival as pre-ECMO days of ventilation increased ($P < .05$). For each additional year of age, survival decreased by an average of 2.5%. For each additional day of pre-ECMO ventilation, survival decreased by an average of 2.9%. Younger ages were generally associated with higher survival probabilities at each ventilation day.

Conclusions: In the pediatric population, survival decreases significantly as pre-ECMO ventilator days increase. Survival is also inversely related to patient age. Thus, patient age and duration of ventilation should be considered when evaluating suitability for ECMO.

22 yr, 2550 children, 58% survival,
Mean Vent days 5.2,
2.5% decrease in survival with each additional day of mechanical ventilation

Extracorporeal membrane oxygenation for pediatric respiratory failure: Survival and predictors of mortality*

Luke A. Zabrocki, MD; Thomas V. Brogan, MD; Kimberly D. Statler, MD; W. Bradley Poss, MD; Michael D. Rollins, MD; Susan L. Bratton, MD

Objective: **The last multicentered analysis of extracorporeal membrane oxygenation in pediatric acute respiratory failure was completed in 1993. We reviewed recent international data to evaluate survival and predictors of mortality.**

Design: **Retrospective case series review.**

Setting: **The Extracorporeal Life Support Organization Registry, which includes data voluntarily submitted from over 115 centers worldwide, was queried. The work was completed at the Division of Pediatric Critical Care, Department of Pediatrics, Primary Children's Medical Center, University of Utah, Salt Lake City, UT.**

Subjects: **Patients aged 1 month to 18 yrs supported with extracorporeal membrane oxygenation for acute respiratory failure from 1993 to 2007.**

Interventions: **None.**

Measurements and Main Results: **There were 3,213 children studied. Overall survival remained relatively unchanged over time at 57%. Considerable variability in survival was found based on pulmonary diagnosis, ranging from 83% for status asthmaticus to 39% for pertussis. Comorbidities significantly decreased survival to 33% for those with renal failure (n = 329), 16% with liver failure (n = 51), and 5% with hematopoietic stem cell transplantation (n = 22). The proportion of patients with comorbidities increased from 19% during 1993 to 47% in 2007. Clinical factors associated with mortality included precannulation ventilatory support longer than 2 wks and lower precannulation blood pH.**

Conclusions: **Although the survival of pediatric patients with acute respiratory failure treated with extracorporeal membrane oxygenation has not changed, this treatment is currently offered to increasingly medically complex patients. Mechanical ventilation in excess of 2 wks before the initiation of extracorporeal membrane oxygenation is associated with decreased survival. (Crit Care Med 2011; 39:364–370)**

KEY WORDS: extracorporeal membrane oxygenation; pediatrics; respiratory insufficiency; comorbidity; mortality; extracorporeal life support; ventilator-induced lung injury

15 yr Data from 115 centers worldwide.

3,213 Peds Resp ECMO: 57% survival. More complex kids with MOSF.

Low pH, > 2weeks of MV associated with increased mortality

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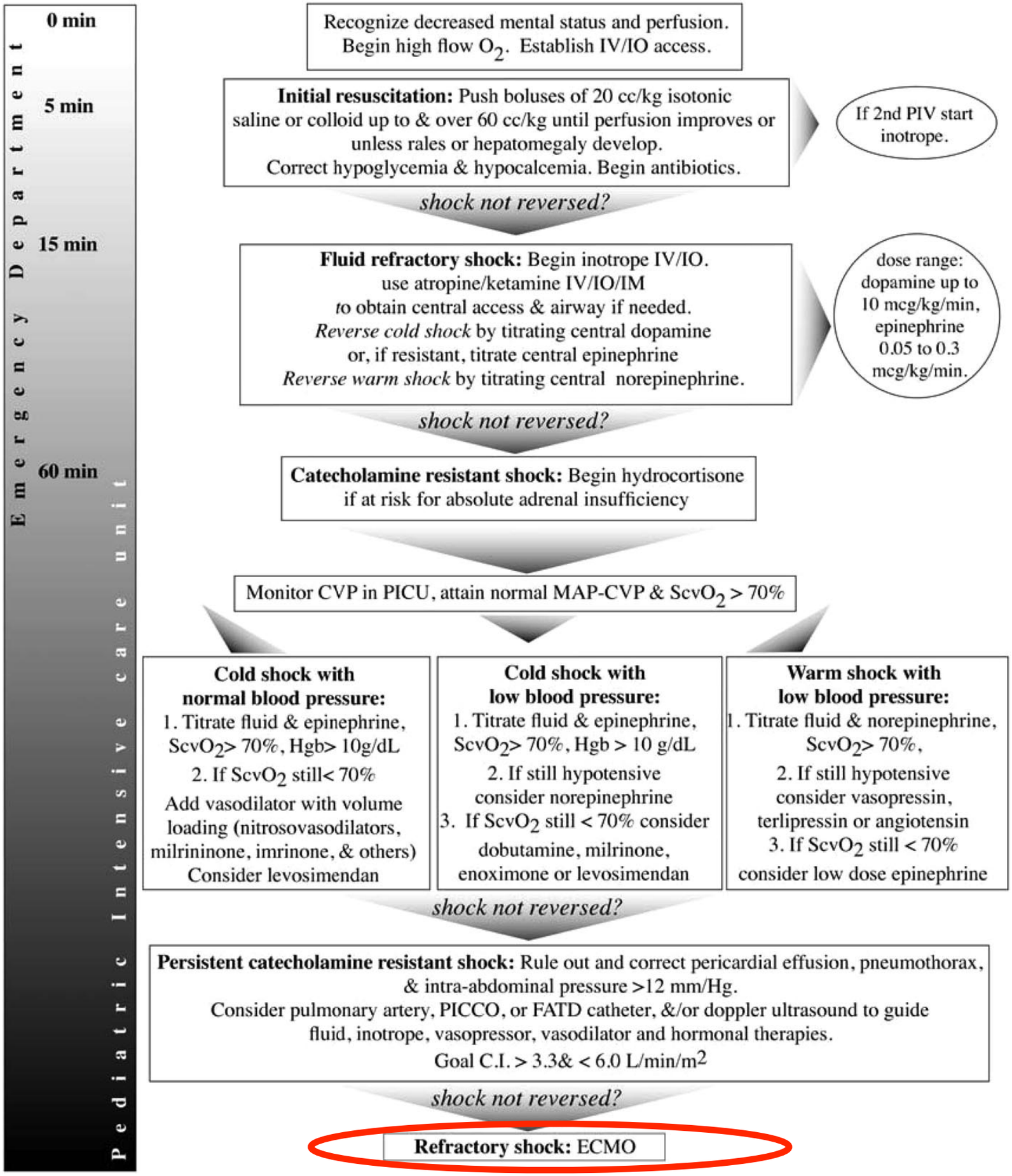


ACCM 2007 Pediatric Septic Shock clinical guidelines

Crit Care Med 2009; 37:666 – 688

Central extracorporeal membrane oxygenation for refractory pediatric septic shock

Graeme MacLaren, MBBS, FCICM, FRACP; Warwick Butt, MBBS, FRACP, FCICM; Derek Best, RN, RSCN, BN; Susan Donath, BSc, MA

Objective: **To demonstrate positive outcome, to achieve higher flow rates, and to reverse shock more quickly by implementing central extracorporeal membrane oxygenation (ECMO) in children with refractory septic shock. Children hospitalized with sepsis have significant mortality rates. The development of shock is the most important risk factor for death. For children with septic shock refractory to all other forms of therapy, ECMO has been recommended but estimated survival is <50% and the best method of applying the technology is unknown. In recent years, our institutional practice has been to cannulate children with refractory septic shock directly through the chest (central, atrioaortic ECMO) to achieve higher blood flow rates.**

Design: **Retrospective case series.**

Setting: **Intensive care unit of a tertiary referral pediatric hospital.**

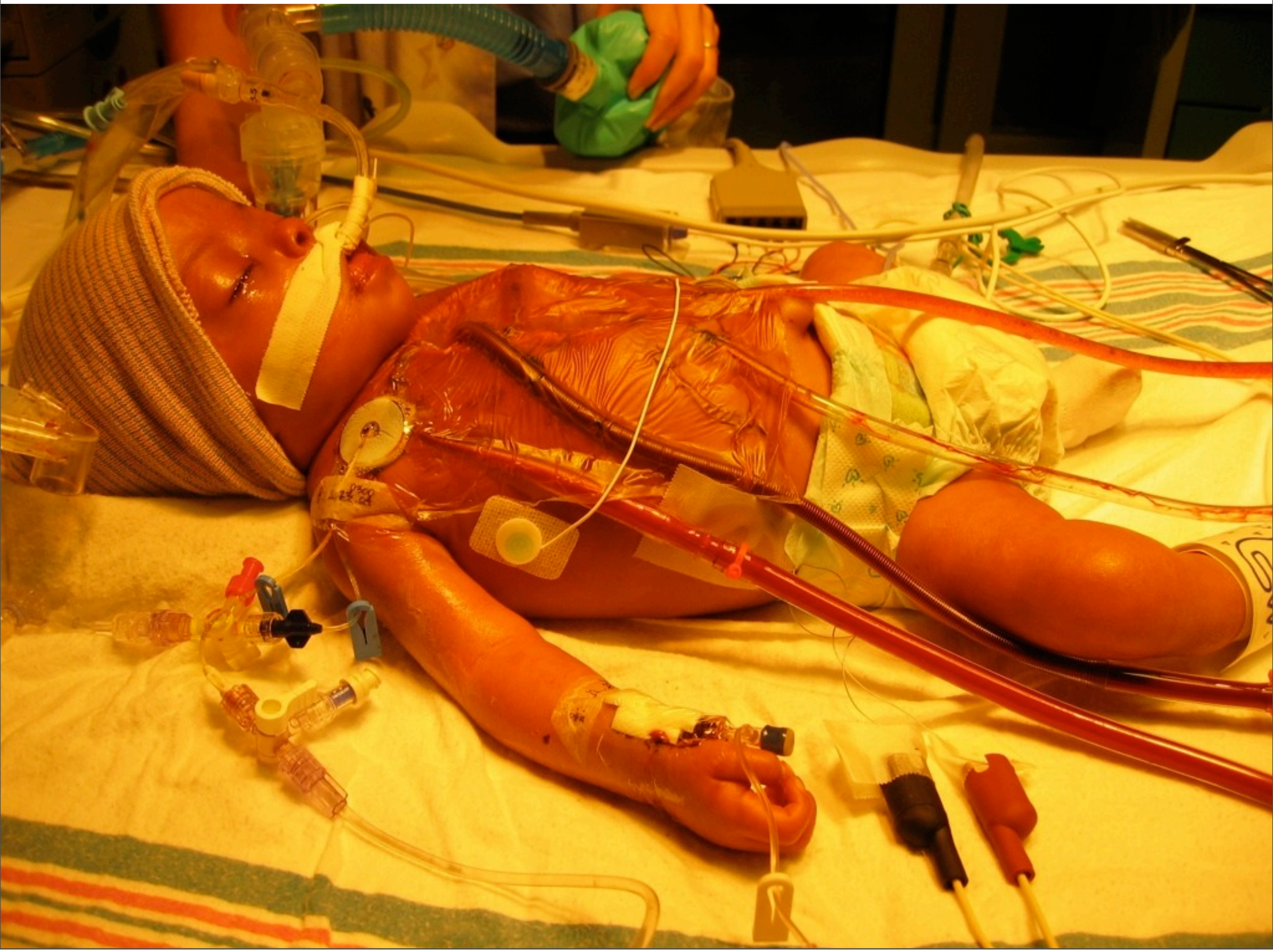
Patients: **Twenty-three children with refractory septic shock who received central ECMO primarily as circulatory support.**

Interventions: **Central ECMO.**

Measurements and Main Results: **The primary outcome measure was survival to hospital discharge. Pre-ECMO circulatory and ventilatory parameters, infecting organism, duration and complications of ECMO and length of hospital stay were also collected. Twenty-three patients (median: age, 6 yrs; weight, 20 kg) over a 9-yr period were included. All patients had microbiological evidence of infection, and meningococcemia was the most common diagnosis. Twenty-two (96%) patients had failure of at least three organ systems, and all patients received at least two inotropes with a mean inotrope score of 82.2 (SD, 115.6). Eight (35%) patients suffered cardiac arrest and required external cardiac massage before ECMO. Eighteen (78%) patients survived to be decannulated off ECMO, and 17 (74%) children survived to hospital discharge. Higher pre-ECMO arterial lactate levels were associated with increased mortality (11.7 mmol/L in nonsurvivors vs. 6.0 mmol/L in survivors, $p = .007$).**

Conclusions: **Central ECMO seems to be associated with better survival than conventional ECMO and should be considered by clinicians as a viable strategy in children with refractory septic shock. (Pediatr Crit Care Med 2011; 12:133–136)**

KEY WORDS: sepsis; septic shock; pediatric; extracorporeal membrane oxygenation; cardiac arrest



Friday, July 13, 12

Pediatric ECMO- Metabolic

- Metabolic disorders- Urea Cycle disorder

- Rapid clearance of Ammonia- ECMO + CRRT= improved outcomes

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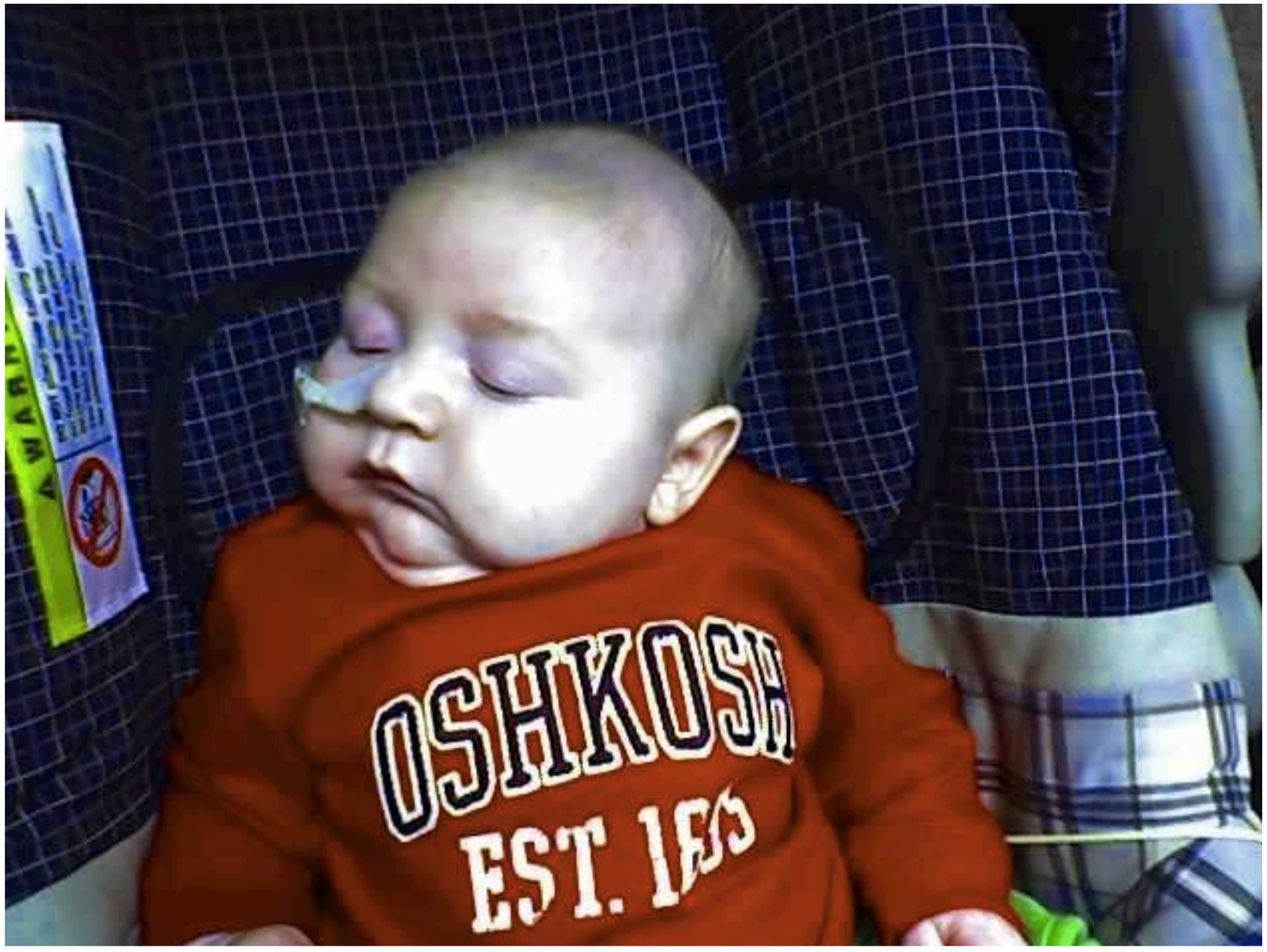
Effective hemodialysis and hemofiltration driven by an extracorporeal membrane oxygenation pump in infants with hyperammonemia

Marshall Summar, MD, John Pietsch, MD, Jayant Deshpande, MD, and Gerald Schulman, MD

From the Departments of Pediatrics, Pediatric Surgery, and Medicine, Vanderbilt University Medical Center, Nashville, Tennessee

Two infants with urea cycle disorders had life-threatening hyperammonemia within the first 5 days of life. Both patients were small for dates, poorly oxygenated, and hemodynamically unstable. We employed a combination of extracorporeal oxygenation and hemodialysis to provide high-flow filtration in a controlled system to rapidly detoxify both patients. (J PEDIATR 1996;128:379-82)



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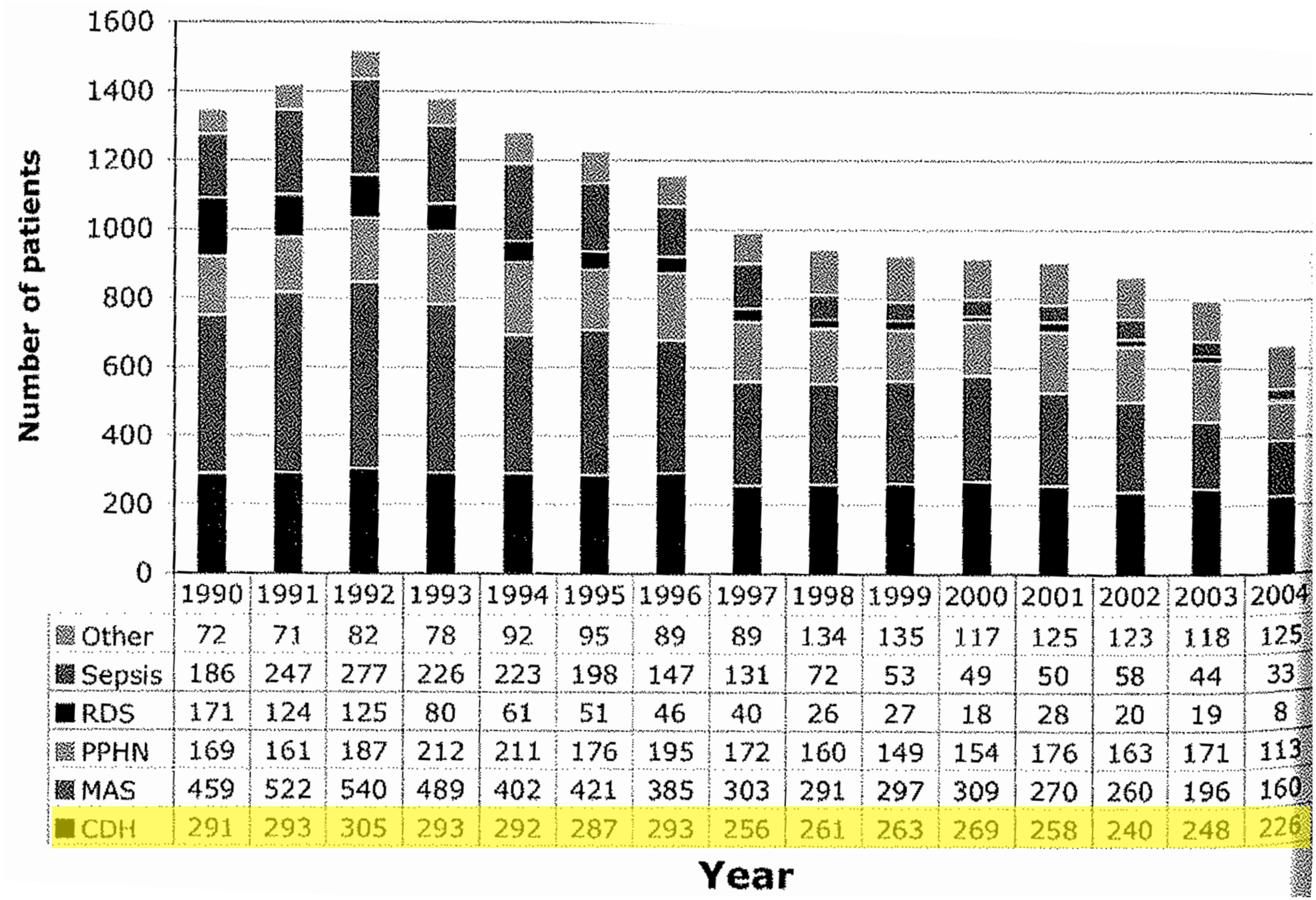
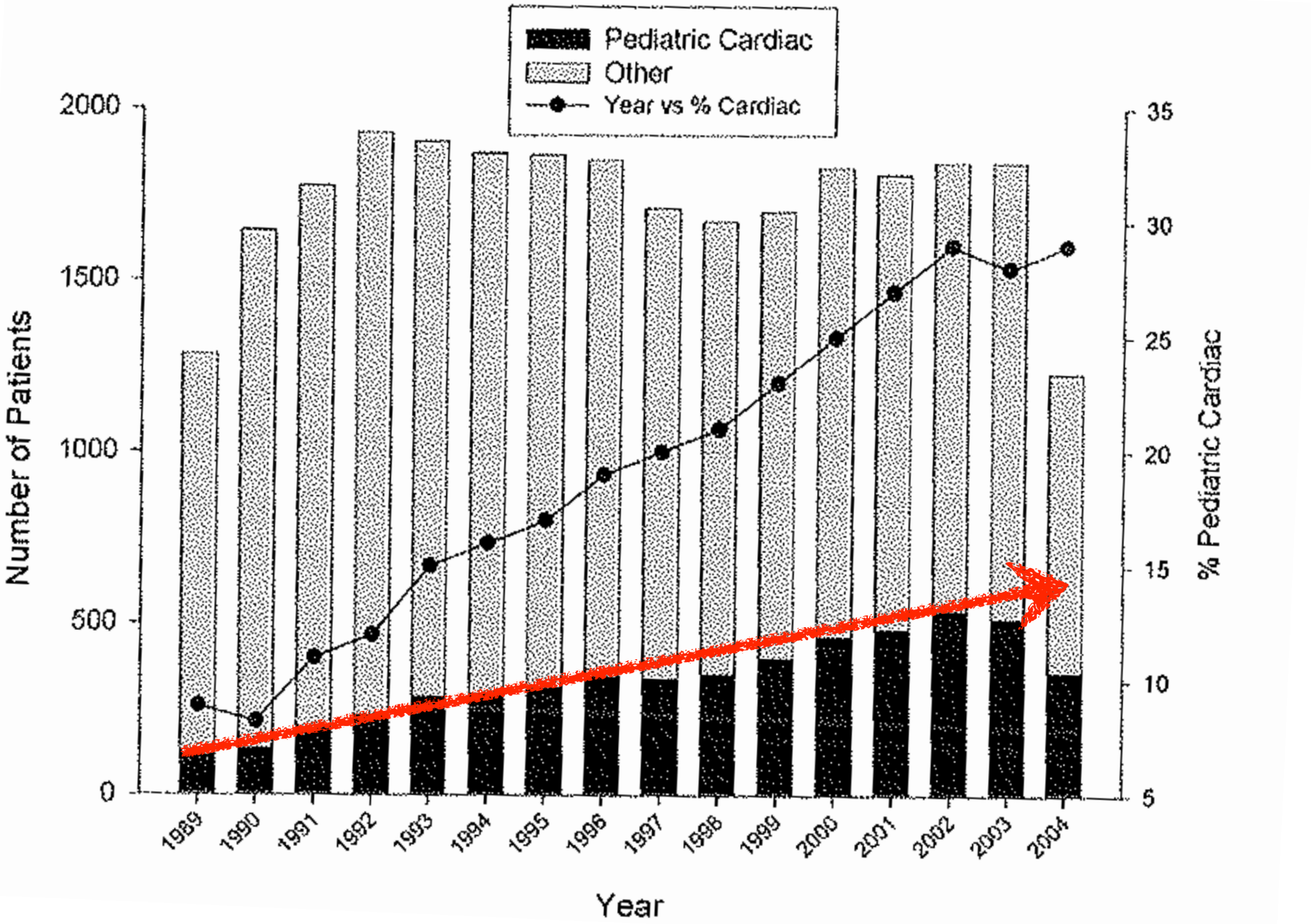


	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Other	72	71	82	78	92	95	89	89	134	135	117	125	123	118	125
Sepsis	186	247	277	226	223	198	147	131	72	53	49	50	58	44	33
RDS	171	124	125	80	61	51	46	40	26	27	18	28	20	19	8
PPHN	169	161	187	212	211	176	195	172	160	149	154	176	163	171	113
MAS	459	522	540	489	402	421	385	303	291	297	309	270	260	196	160
CDH	291	293	305	293	292	287	293	256	261	263	269	258	240	248	226

ELSO Red book, 3rd edition 2005



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ELSO Red book, 3rd edition 2005

ELSO Results 2004 survival to hospital discharge

- Neonatal Respiratory Failure 78%
- Neonatal Cardiac Failure 37%
- Pediatric Respiratory Failure 55%
- Pediatric Cardiac Failure 42%

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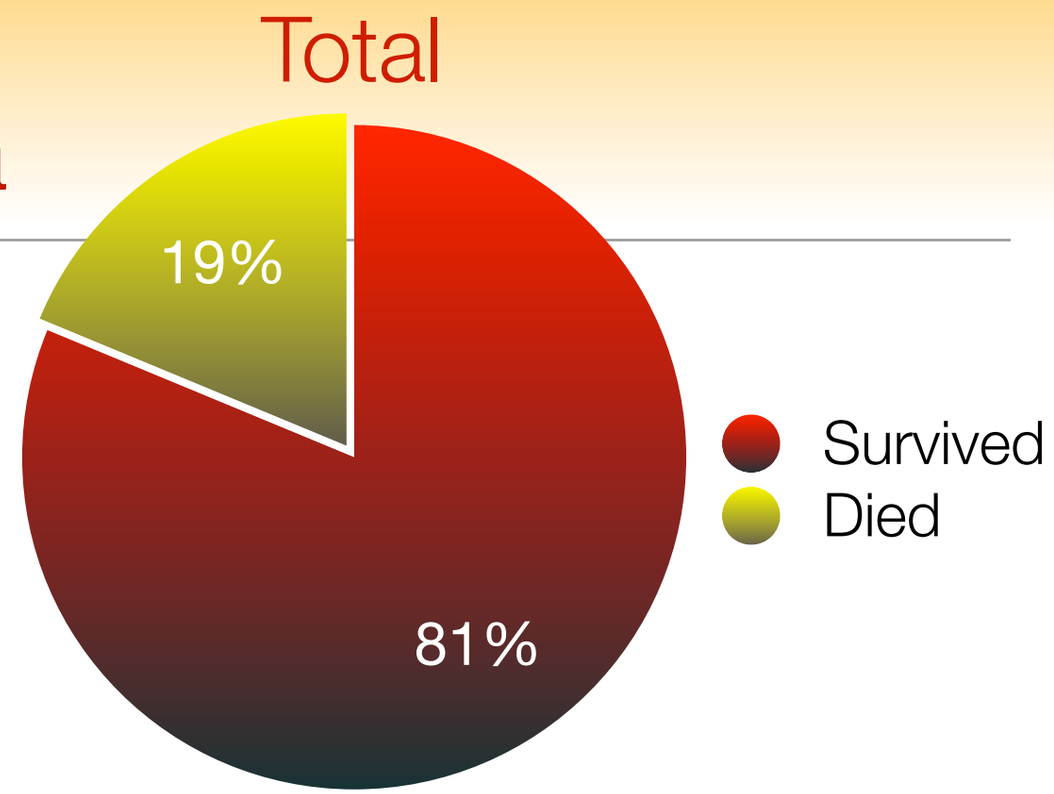
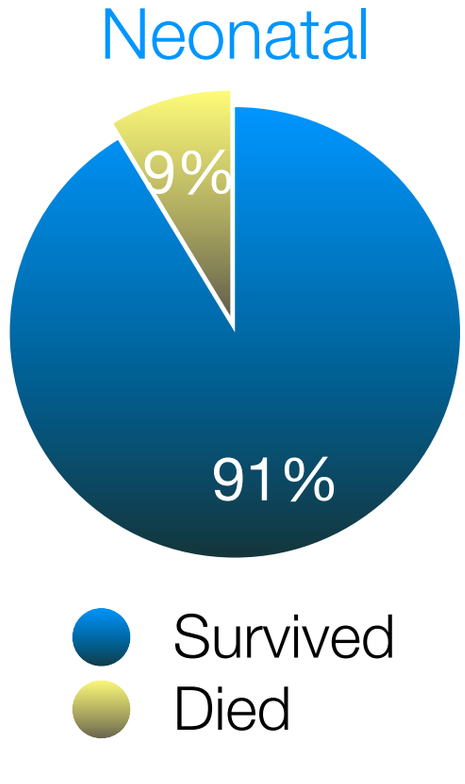
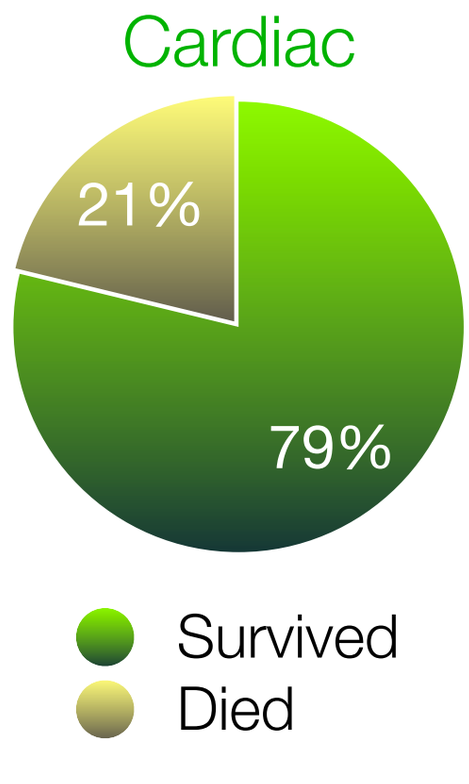
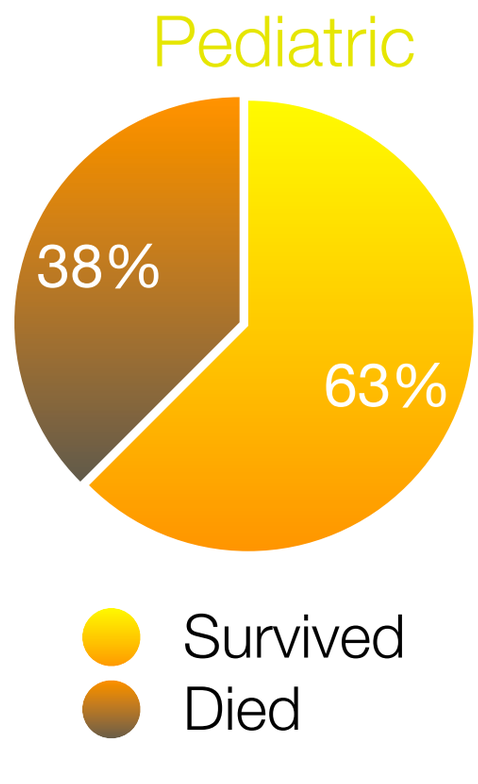
Children's 2010 Data

- 64 total cases- 52 survived
- 23 neonate- 21 survived
- 33 cardiac- 26 survived
- 8 pediatric- 5 survived









Adult ECMO- Evolution

Extracorporeal Membrane Oxygenation in Severe Acute Respiratory Failure

A Randomized Prospective Study

Warren M. Zapol, MD; Michael T. Snider, MD, PhD; J. Donald Hill, MD; Robert J. Fallat, MD; Robert H. Bartlett, MD; L. Henry Edmunds, MD; Alan H. Morris, MD; E. Converse Peirce II, MD; Arthur N. Thomas, MD; Herbert J. Proctor, MD; Philip A. Drinker, PhD; Philip C. Pratt, MD; Anna Bagniewski, MA; Rupert G. Miller, Jr, PhD

• Nine medical centers collaborated in a prospective randomized study to evaluate prolonged extracorporeal membrane oxygenation (ECMO) as a therapy for severe acute respiratory failure (ARF). Ninety adult patients were selected by common criteria of arterial hypoxemia and treated with either conventional mechanical ventilation (48 patients) or mechanical ventilation supplemented with partial venoarterial bypass (42 patients). Four patients in each group survived. The majority of patients suffered acute bacterial or viral pneumonia (57%). All nine patients with pulmonary embolism and six patients with posttraumatic acute respiratory failure died. The majority of patients died of progressive reduction of transpulmonary gas exchange and decreased compliance due to diffuse pulmonary inflammation, necrosis, and fibrosis. We conclude that ECMO can support respiratory gas exchange but did not increase the probability of long-term survival in patients with severe ARF.

(*JAMA* 242:2193-2196, 1979)

was launched to determine how useful it was. We describe a randomized, prospective, and collaborative study of the effect of several days of bypass with a membrane artificial lung on the chances that adults will survive severe ARF.

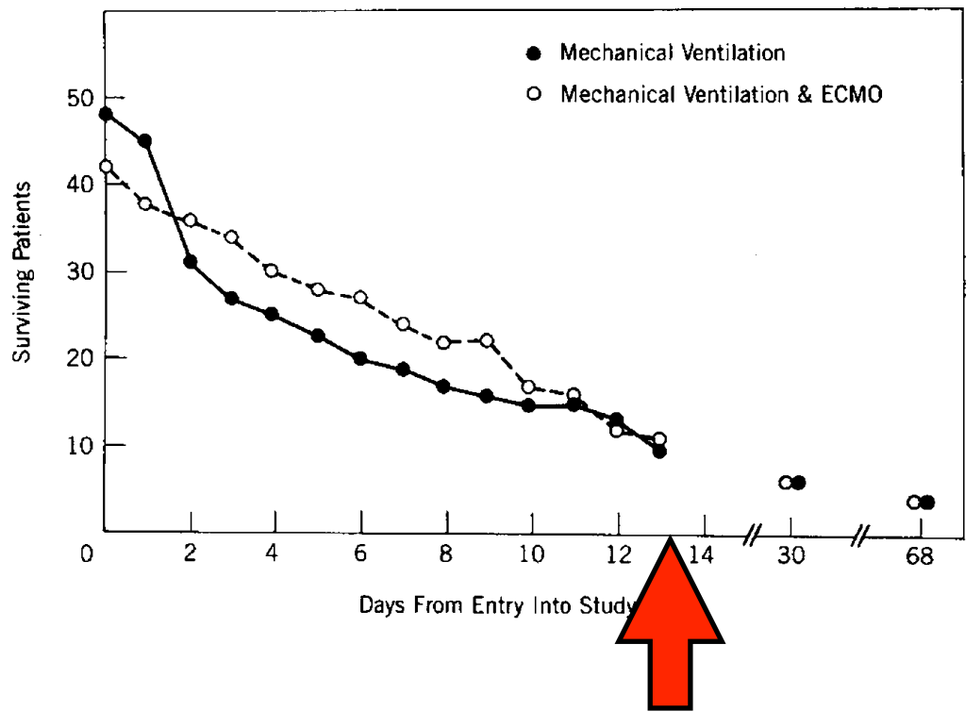
When this study was conceived, membrane oxygenators had been used for long-term bypass of normal animals[1]; the results were promising. By 1974, 150 patients suffering from ARF of varying causes and severity had undergone bypass; approximately 10% to 15% had survived.[7] For some, the incidence of survival was even

9 centers, PF <50 on PEEP>5.
92% death in conv MV, 86% in ECMO
All Fem VA,No true lung rest settings.
Average bleeding day1 3.8 litres/day !
High ACT targets
6 of 9 ctr no ECMO experience
Mean LOMV pre-random: 9.6 d

Therapy*	Patient Outcome: Dead—Respiratory Improvement Never Occurred	Dead After Respiratory Improvement	Survived After Respiratory Improvement
ECMO and MV	34	4	4
MV (control)	41	3	4

*ECMO indicates extracorporeal membrane oxygenation; MV, mechanical ventilation.

Fig 2.—Number of surviving patients treated by either mechanical ventilation alone (control group) or supplemented with partial venoarterial bypass plotted against days after entry into study. From day 2 to day 11, there were greater number of surviving patients in bypass group: ECMO, extracorporeal membrane oxygenation.



JAMA 1979, 242: 2193-96

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AMERICAN JOURNAL OF
Respiratory and
Critical Care Medicine®

Am. J. Respir. Crit. Care Med., Vol 149, No. 2, Feb 1994, 295-305.

Randomized clinical trial of pressure-controlled inverse ratio ventilation and extracorporeal CO2 removal for adult respiratory distress syndrome [published erratum appears in Am J Respir Crit Care Med 1994 Mar;149(3 Pt 1):838]

AH Morris, CJ Wallace, RL Menlove, TP Clemmer, JF Orme Jr, LK Weaver, NC Dean, F Thomas, TD East and NL Pace
Department of Medicine, LDS Hospital, Salt Lake City, Utah 84143.

The impact of a new therapy that includes pressure-controlled inverse ratio ventilation followed by extracorporeal CO2 removal on the survival of patients with severe ARDS was evaluated in a randomized controlled clinical trial. Computerized protocols generated around-the- clock instructions for management of arterial oxygenation to assure equivalent intensity of care for patients randomized to the new therapy limb and those randomized to the control, mechanical ventilation limb. We randomized 40 patients with severe ARDS who met the ECMO entry criteria. The main outcome measure was survival at 30 days after randomization. Survival was not significantly different in the 19 mechanical ventilation (42%) and 21 new therapy (extracorporeal) (33%) patients (p = 0.8). All deaths occurred within 30 days of randomization. Overall patient survival was 38% (15 of 40) and was about four times that expected from historical data (p = 0.0002). Extracorporeal treatment group survival was not significantly different from other published survival rates after extracorporeal CO2 removal. Mechanical ventilation patient group survival was significantly higher than the 12% derived from published data (p = 0.0001). Protocols controlled care 86% of the time. Average PaO2 was 59 mm Hg in both treatment groups. Intensity of care required to maintain arterial oxygenation was similar in both groups (2.6 and 2.6 PEEP changes/day; 4.3 and 5.0 FIO2 changes/day). We conclude that there was no significant difference in survival between the mechanical ventilation and the extracorporeal CO2 removal groups. We do not recommend extracorporeal support as a therapy for ARDS. Extracorporeal support for ARDS should be restricted to controlled clinical trials.

Single center, 40 patients meeting ECMO criteria- PCIRV vs ECCO2R
Survival @ D30 was 42%MV vs 33% ECCO2R
Overall survival 4 times greater
However, Needed higher PIP in ECCO2R to maintain adequate oxygenation

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Once burnt/ bitten twice shy !

THE LANCET

Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial

Giles J Peek, Miranda Mugford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Mariamma M Thalanany, Clare L Hibbert, Ann Truesdale, Felicity Clemens, Nicola Cooper, Richard K Firmin, Diana Elbourne, for the CESAR trial collaboration

Lancet 2009; 374:1351-63

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766 patients screened for eligibility

586 excluded
103 bed unavailable for ECMO
99 had Murray score <3·0 or pH >7·20
86 had high-pressure ventilation for >7 days
298 other*

180 enrolled and randomly allocated to treatment

90 assigned for consideration to receive ECMO

90 assigned to receive conventional management

22 did not receive ECMO
16 improved with conventional management
3 died within 48 h before transfer
2 died during transfer
1 had contraindication to heparin†

68 received ECMO support

90 received conventional management

3 withdrew from the study before 6-month follow-up

90 reached primary outcome

87 reached primary outcome;
90 continued to be assessed for 6-month follow-up

33 died before 6 months

44 died before 6 months

57 eligible for 6-month follow-up

46 eligible for 6-month follow-up‡

3 withdrew from the study and had no information about severe disability at 6 months

5 had restricted information about status at 6 months from GP or hospital data

11 had restricted information about status at 6 months from GP or hospital data

52 assessed at 6 months

32 assessed at 6 months

Figure 1: **Trial profile**

ECMO=extracorporeal membrane oxygenation. *81 were contraindicated to continue with treatment, 35 were only enquiries, 35 received advice on optimum conventional management, 33 refused assent, 31 had contraindications to limited heparinisation, 30 were younger than 18 years or older than 65 years, 28 had the treating clinician refuse enrolment, eight had an improving condition, seven had no relatives available to provide assent, four died before randomisation, three had intracranial bleeding, two were given advice on ECMO treatment, and one had had previous surgical treatment. †Patient needed amputation and therefore could not be heparinised. ‡Includes one patient with follow-up assessment at 6 months in hospital and who died after 6 months without leaving hospital.

Findings 766 patients were screened; 180 were enrolled and randomly allocated to consideration for treatment by ECMO (n=90 patients) or to receive conventional management (n=90). 68 (75%) patients actually received ECMO; 63% (57/90) of patients allocated to consideration for treatment by ECMO survived to 6 months without disability compared with 47% (41/87) of those allocated to conventional management (relative risk 0·69; 95% CI 0·05–0·97, p=0·03). Referral to consideration for treatment by ECMO treatment led to a gain of 0·03 quality-adjusted life-years (QALYs) at 6-month follow-up. A lifetime model predicted the cost per QALY of ECMO to be £19 252 (95% CI 7622–59 200) at a discount rate of 3·5%.

Interpretation We recommend transferring of adult patients with severe but potentially reversible respiratory failure, whose Murray score exceeds 3·0 or who have a pH of less than 7·20 on optimum conventional management, to a centre with an ECMO-based management protocol to significantly improve survival without severe disability. This strategy is also likely to be cost effective in settings with similar services to those in the UK.

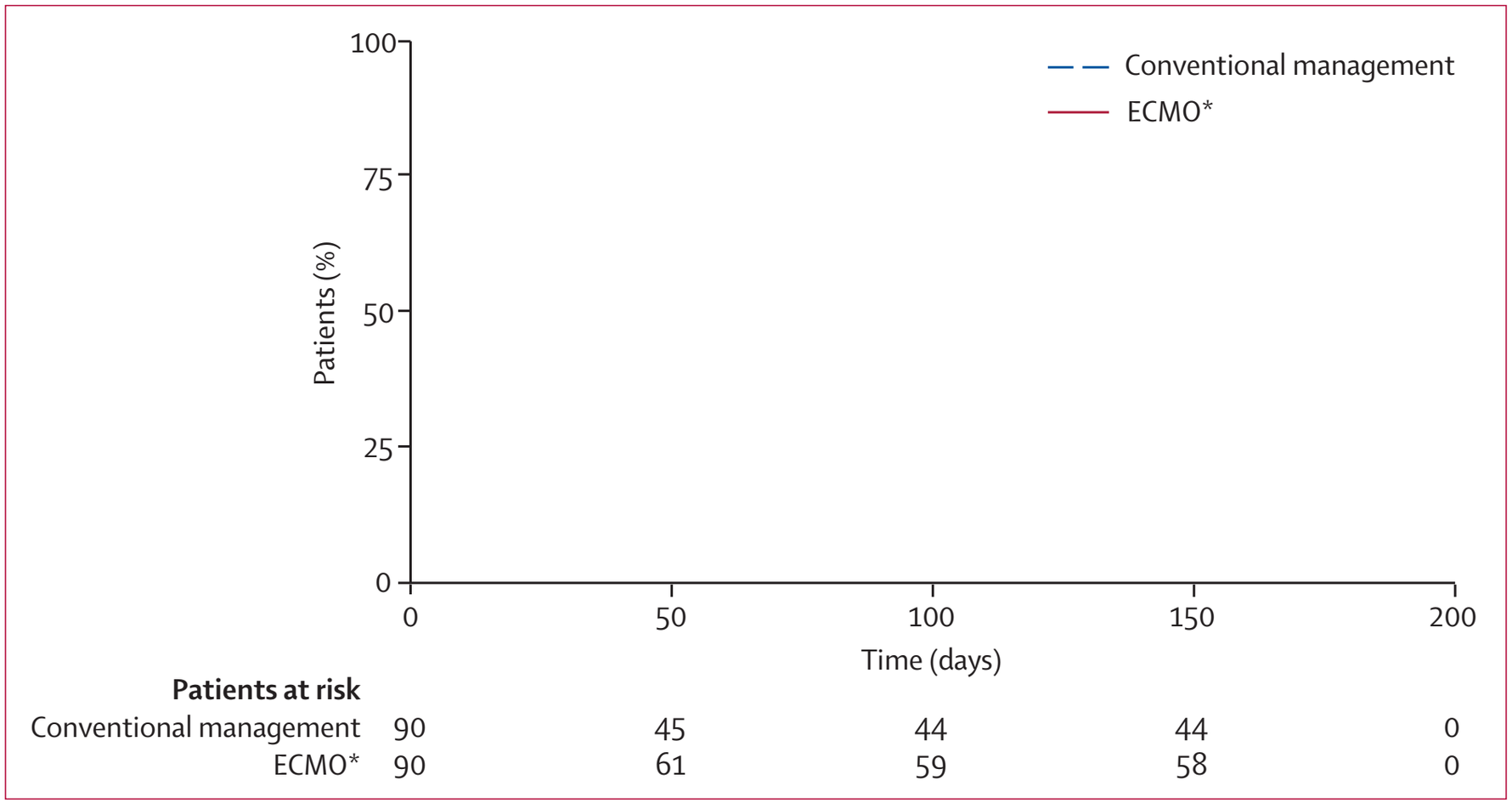

Figure 2: **Kaplan-Meier survival estimates**
ECMO=extracorporeal membrane oxygenation. *Patients were randomly allocated to consideration for treatment by ECMO, but did not necessarily receive this treatment.

Extracorporeal Membrane Oxygenation for 2009 Influenza A(H1N1) Acute Respiratory Distress Syndrome

The Australia and New Zealand Extracorporeal Membrane Oxygenation (ANZ ECMO) Influenza Investigators*

Context The novel influenza A(H1N1) pandemic affected Australia and New Zealand during the 2009 southern hemisphere winter. It caused an epidemic of critical illness and some patients developed severe acute respiratory distress syndrome (ARDS) and were treated with extracorporeal membrane oxygenation (ECMO).

Objectives To describe the characteristics of all patients with 2009 influenza A(H1N1)–associated ARDS treated with ECMO and to report incidence, resource utilization, and patient outcomes.

Design, Setting, and Patients An observational study of all patients (n=68) with 2009 influenza A(H1N1)–associated ARDS treated with ECMO in 15 intensive care units (ICUs) in Australia and New Zealand between June 1 and August 31, 2009.

Main Outcome Measures Incidence, clinical features, degree of pulmonary dysfunction, technical characteristics, duration of ECMO, complications, and survival.

Results Sixty-eight patients with severe influenza-associated ARDS were treated with ECMO, of whom 61 had either confirmed 2009 influenza A(H1N1) (n=53) or influenza A not subtyped (n=8), representing an incidence rate of 2.6 ECMO cases per million population. An additional 133 patients with influenza A received mechanical ventilation but no ECMO in the same ICUs. The 68 patients who received ECMO had a median (interquartile range [IQR]) age of 34.4 (26.6-43.1) years and 34 patients (50%) were men. Before ECMO, patients had severe respiratory failure despite advanced mechanical ventilatory support with a median (IQR) PaO_2/fraction of inspired oxygen (FIO_2) ratio of 56 (48-63), positive end-expiratory pressure of 18 (15-20) cm H_2O, and an acute lung injury score of 3.8 (3.5-4.0). The median (IQR) duration of ECMO support was 10 (7-15) days. At the time of reporting, 48 of the 68 patients (71%; 95% confidence interval [CI], 60%-82%) had survived to ICU discharge, of whom 32 had survived to hospital discharge and 16 remained as hospital inpatients. Fourteen patients (21%; 95% CI, 11%-30%) had died and 6 remained in the ICU, 2 of whom were still receiving ECMO.

Conclusions During June to August 2009 in Australia and New Zealand, the ICUs at regional referral centers provided mechanical ventilation for many patients with 2009 influenza A(H1N1)–associated respiratory failure, one-third of whom received ECMO. These ECMO-treated patients were often young adults with severe hypoxemia and had a 21% mortality rate at the end of the study period.

JAMA. 2009;302(17):1888-1895

www.jama.com

In April 2009, the Mexican Ministry of Health reported an increase in severe pneumonia cases in young adults.[1] The 2009 novel swine-origin influenza A(H1N1) virus was identified as its cause and rapidly led to a worldwide pandemic.[2] This pandemic began in the northern hemisphere during late spring and early summer and appeared to decrease in intensity within a few weeks.[3] Shortly after,

Extracorporeal Membrane Oxygenation

Consider extracorporeal CPR for in-hospital cardiac arrest refractory to initial resuscitation attempts if the condition leading to cardiac arrest is reversible or amenable to heart transplantation, if excellent conventional CPR has been performed after no more than several minutes of no-flow cardiac arrest (arrest time without CPR), and if the institution is able to rapidly perform extracorporeal membrane oxygenation(**Class IIb**; LOE 561,62).

Long-term survival is possible even after 50 minutes of CPR in selected patients.61,62

Outcomes of ECPR

- Multiple case reports & series showing 10-39% survival after ECPR
- No prospective data, case series biased by a large number of children with congenital heart disease.
- Length of conventional CPR prior to ECMO doesn't consistently correlate with outcomes.
- Large series (80 children from Toronto, 66 from CHOP) in recent years (median duration of CPR 46 min Toronto, 50 min (5-105min) CHOP)
  (J Thorac Cardiovasc Surg 2007;134:952-9 and Pediatric Critical Care Med 2004:440)
- ELSO database 695 cases, 38% survival to discharge **(*Circulation*. 2007;116:1693-1700)**

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Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis

Yih-Sharng Chen, Jou-Wei Lin*, Hsi-Yu Yu, Wen-Je Ko, Jih-Shuin Jerng, Wei-Tien Chang, Wen-Jone Chen, Shu-Chien Huang, Nai-Hsin Chi, Chih-Hsien Wang, Li-Chin Chen, Pi-Ru Tsai, Sheoi-Shen Wang, Juey-Jen Hwang, Fang-Yue Lin*

Lancet 2008; 372: 554–61

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See **Comment** page 512

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Correspondence to: Fang-Yue Lin, Department of Surgery, National Taiwan University Hospital, Taipei 100, Taiwan
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Summary

Background Extracorporeal life-support as an adjunct to cardiac resuscitation has shown encouraging outcomes in patients with cardiac arrest. However, there is little evidence about the benefit of the procedure compared with conventional cardiopulmonary resuscitation (CPR), especially when continued for more than 10 min. We aimed to assess whether extracorporeal CPR was better than conventional CPR for patients with in-hospital cardiac arrest of cardiac origin.

Methods We did a 3-year prospective observational study on the use of extracorporeal life-support for patients aged 18–75 years with witnessed in-hospital cardiac arrest of cardiac origin undergoing CPR of more than 10 min compared with patients receiving conventional CPR. A matching process based on propensity-score was done to equalise potential prognostic factors in both groups, and to formulate a balanced 1:1 matched cohort study. The primary endpoint was survival to hospital discharge, and analysis was by intention to treat. This study is registered with ClinicalTrials.gov, number NCT00173615.

Findings Of the 975 patients with in-hospital cardiac arrest events who underwent CPR for longer than 10 min, 113 were enrolled in the conventional CPR group and 59 were enrolled in the extracorporeal CPR group. Unmatched patients who underwent extracorporeal CPR had a higher survival rate to discharge (log-rank p<0·0001) and a better 1-year survival than those who received conventional CPR (log rank p=0·007). Between the propensity-score matched groups, there was still a significant difference in survival to discharge (hazard ratio [HR] 0·51, 95% CI 0·35–0·74, p<0·0001), 30-day survival (HR 0·47, 95% CI 0·28–0·77, p=0·003), and 1-year survival (HR 0·53, 95% CI 0·33–0·83, p=0·006) favouring extracorporeal CPR over conventional CPR.

Interpretation Extracorporeal CPR had a short-term and long-term survival benefit over conventional CPR in patients with in-hospital cardiac arrest of cardiac origin.

Funding National Science Council, Taiwan.

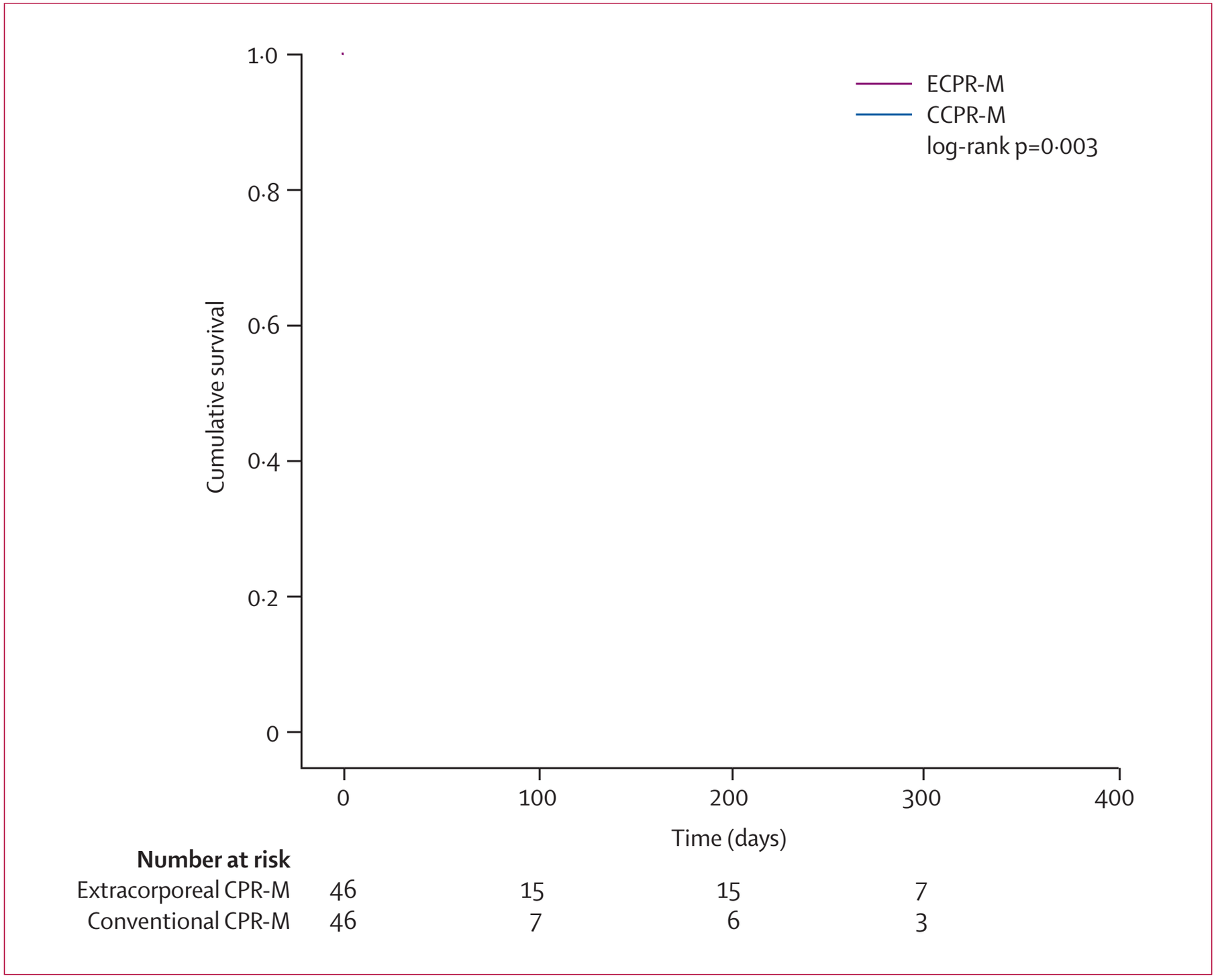


Figure 3: **Kaplan-Meier plot of the survival curves in the extracorporeal CPR-M and conventional CPR-M groups for 1 year**

Extracorporeal Membrane Oxygenation to Support Cardiopulmonary Resuscitation in Adults

Ravi R. Thiagarajan, MBBS, MPH, Thomas V. Brogan, MD, Mark A. Scheurer, MD, Peter C. Laussen, MBBS, Peter T. Rycus, MPH, and Susan L. Bratton, MD, MPH

Department of Cardiology, Children's Hospital Boston and Department of Pediatrics, Harvard Medical School, Boston, Massachusetts; Department of Pediatric Critical Care Medicine, Children's Hospital and Regional Medical Center and the University of Washington, Seattle, Washington; Extracorporeal Life Support Organization, University of Michigan, Ann Arbor, Michigan; and Department of Pediatrics, University of Utah, and Primary Children's Medical Center, Salt Lake City, Utah

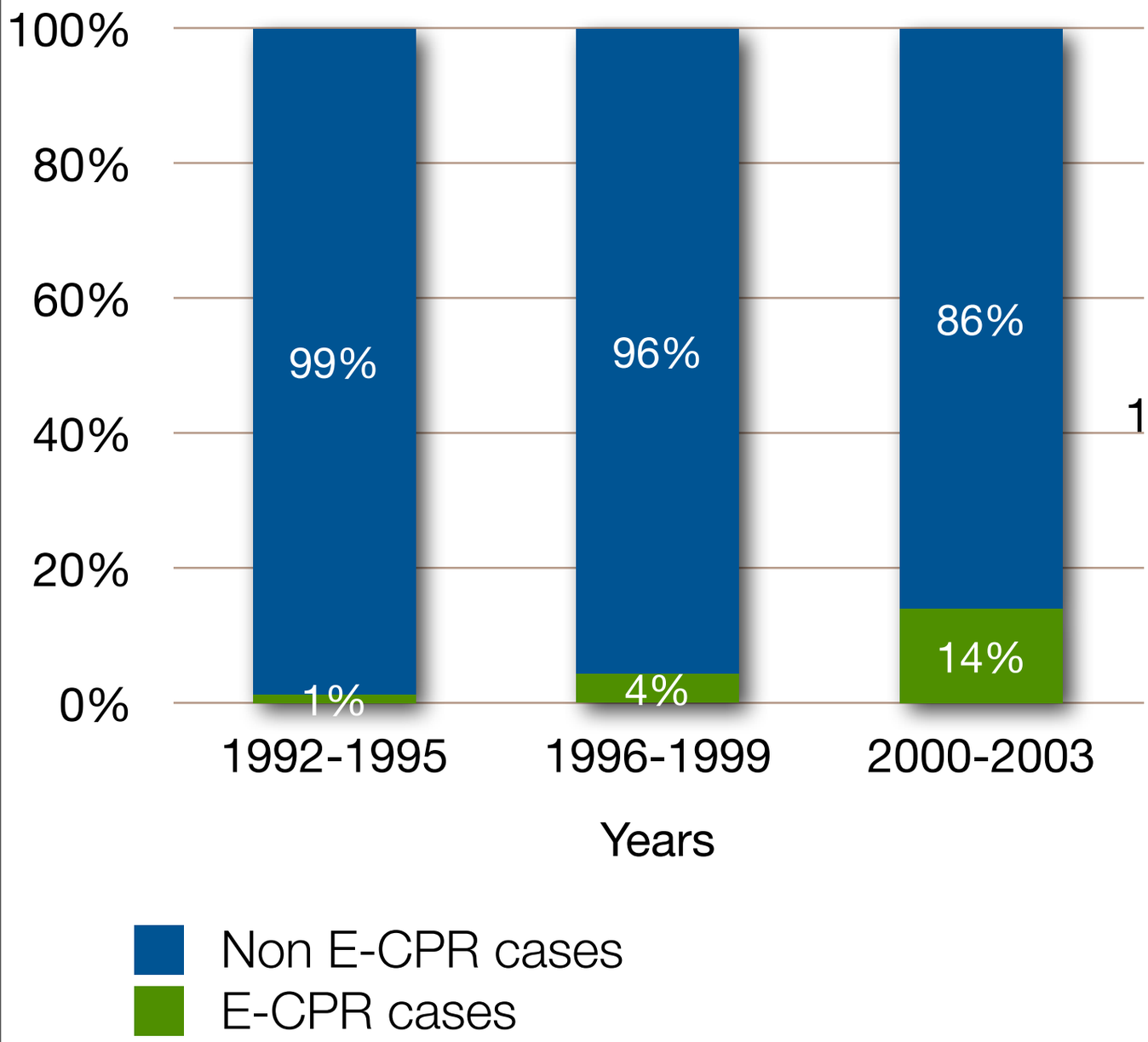
Background. **Extracorporeal membrane oxygenation (ECMO) to support cardiopulmonary resuscitation (CPR) has been shown to improve survival in children and adults. We describe outcomes after the use of ECMO to support CPR (E-CPR) in adults using multiinstitutional data from the Extracorporeal Life Support Organization (ELSO) registry.**

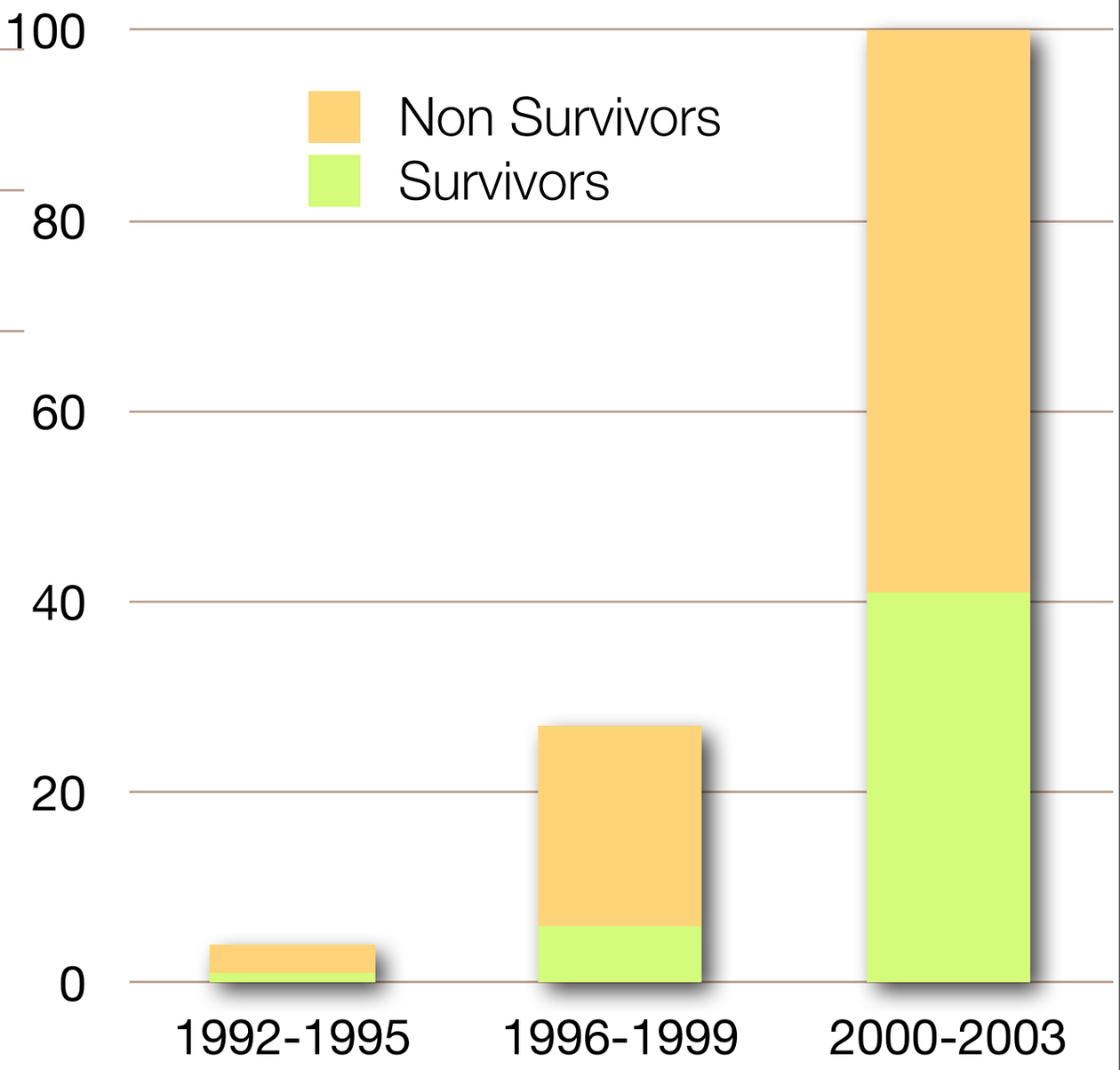
Methods. **Patients greater than 18 years of age using ECMO to support CPR (E-CPR) during 1992 to 2007 were extracted from the ELSO registry and analyzed.**

Results. **Two hundred and ninety-seven (11% of 2,633 adult ECMO uses) reports of E-CPR use in 295 patients were analyzed. Median age was 52 years (interquartile range [IQR], 35, 64) and most patients had cardiac disease (n = 221; 75%). Survival to hospital discharge was 27%. Brain death occurred in 61 (28%) of nonsurvivors. In a multivariate logistic regression model, pre-ECMO factors including a diagnosis of acute myocarditis (odds ratio [OR]: 0.18; 95% confidence interval [CI]: 0.05 to 0.69) compared with noncardiac diagnoses and use of percutaneous cannulation technique (OR: 0.42; 95% CI: 0.21 to 0.87) lowered odds of mortality, whereas a lower pre-ECMO arterial blood partial pressure of oxygen (Pa_{O_2}) less than 70 mm Hg (OR: 2.7; 95% CI: 1.21 to 6.07) compared with a Pa_{O_2} of 149 mm Hg or greater increased odds of mortality. The need for renal replacement therapy during ECMO increased odds of mortality (OR: 2.41; 95% CI: 1.34 to 4.34).**

Conclusions. **The use of E-CPR was associated with survival in 27% of adults with cardiac arrest facing imminent mortality. Further studies are warranted to evaluate and better define patients who may benefit from E-CPR.**

(Ann Thorac Surg 2009;87:778–85)





Thiagarajan et al; Ann Thorac Surg 2009; 87:778

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PEDIATRIC ORIGINAL

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Duration of resuscitation prior to rescue extracorporeal membrane oxygenation impacts outcome in children with heart disease

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Abstract *Purpose:* Survival outcomes in children with heart disease after use of either non-emergent extracorporeal membrane oxygenation (ECMO) or cardiopulmonary resuscitation (CPR) onto ECMO (ECPR) are comparable. Concerns remain regarding the impact of CPR duration on survival and neurological outcome. *Methods:* Children with cardiac disease requiring ECMO were identified from our database. Demographic, operative and ECMO details were evaluated with respect to survival. In addition, resuscitation details were extracted for the recent subgroup requiring ECPR; these details were evaluated with respect to survival and neurological outcomes at midterm follow-up by univariate analysis and multivariable logistic regression. *Results:* There were 126 ECMO runs in 116 children; 61 (53%) received ECPR. Forty-eight (41%) children survived to discharge; survival in the most recent era was 48%. Thirty-seven children underwent ECPR in the most recent era with 14 (38%) surviving to discharge. Duration of cardiopulmonary resuscitation differed significantly between survivors and nonsurvivors (15 vs. 40 min, $p = 0.009$); children requiring ≥30 min of CPR had 79% reduced odds of hospital survival (OR = 0.21, 95% CI = 0.05–0.96, $p = 0.04$). Two children died after hospital discharge; with 33% having paediatric cerebral performance category scores ≤2. Poor neurological outcome was associated with longer duration of CPR (32 vs. 17.5 min, $p = 0.03$). *Conclusions:* Despite comparable survival outcomes between ECPR and non-emergent ECMO in children with cardiac disease a significant association between CPR duration and outcome (survival and neurological) was noted in this population.

Keywords Congenital heart disease · Cardiac arrest · Extracorporeal · Outcomes · Cardiopulmonary resuscitation · Paediatrics

ECMO ROLES AND PROCEDURES FLOW MAP

Phase 1 Arrest & Code Blue

RN TEAM LEADER
ASSIGNS ROLES & MAINTAINS SITUATIONAL AWARENESS
1. Recorder RN
2. CPR RN
3. Med RN 1
4. Med RN 2
5. BedSide 2
6. PCT/PSA

BED SIDE RN 1
Initiates Code Blue

TEAM LEAD MD
RUNS RESUSCITATION OF PATIENT
Maintains Situational Awareness

Bed Side RN 1
Initiates CPR

Recorder RN:
1. Records all activities on CPR sheet
2. Provides Medication Time Ques

PCT 1
Brings Code Cart to rm

Places Defibrillator on bedside table

Clears rm of excess equipment and chairs

Moves 2 bedside tables to foot of bed

PSA 2
Brings Ice to Head

Moves ECMO cart to outside rm

Grabs extra suction canister from ECMO cart and sets up suction

Grabs I STAT and cartridges & puts on nurse server

UCA
Pages CICU Attending

Pages CV Surg on Call

Documents time of call backs

CPR RN
Takes Over CPR

Directs CPR Rotation with Available Staff and RN Team Leader

Med RN 1 w/ Pharm
Prepares Prepare 5 Rounds of Epi

Prepares Volume (NS)

Prepares 2 Rounds:
Ca Cl
Bicarb

Meds as ordered by MD Lead

Med RN 2
Prepares Drips and Tubing (Partner with Med RN 1 and double checks all meds)

Prepares Other meds as needed in communication with Med RN 1

Bed Side RN 1:
Line Patency?

Yes
Bed Side RN 1
Admin Medication

NO: Bed Side RN 1
Admin Meds Via ETT If Avail

MD Assist
Stable Airway

NO: MD Assist
Establishes Airway

Yes, Airway Stable
Assess IV Access,
Inserts Line
If Needed

RT
Secures Airway

Places Patient on Vent

Position and Secures airway circuit to HOB

Provides rotational assistance with CPR Team

DECISION TO INITIATE ECMO MADE BY MD LEAD MOVE TO PHASE2

Phase 2 E-CPR Initiation

RN TEAM LEADER:
Ensures Completion of Bld Obtainment
Assigns PCT to Retrieve Bld
Maintains Situational Awareness
Completion of Cerner Order
-Comp of Bld Forms
-Assigns PCT for Bld Pick Up
-Communicates Bld Status with MD Lead

Recorder RN:
Con't same duties

PCT 1
Takes T&C to BB or Retrieves Bld from BB w/ "Bld Pick up Request Form" AND Emerg Release Form – if needed

PSA 2
Moves Bovie and Head Lamp into Room

Grabs Hats, Masks and Gloves for All Sterile Staff

UCA Calls 2222 RD with rm num and weight

UCA Notifies BB of Rapid and determines need for T& C

Communicate...

CPR RN
Cont CPR Rotation with Extra Staff in rm

MED RN 1
Cont Code Meds Prep

Prepares Heparin 50u/kg x2 Ancef (50mg/ kg) Fent (10 mc...

Med RN 2
Pulls pt ECMO meds from Cart

Pulls Fent from Pyxis

Prepar...

Bed Side RN 1
Con't Admin of Code Meds Per MD LEAD

Draw T&C

Ass...

Bed Side RN 2
Prepares extra lines for meds and A-line

Moves EKG Leads

Pac...

...d Lamp

Moving Boom and Vent for ECMO pump with RT

...mg/kg)

MD Lead
Continues to Lead R...

Determines Projected Time Line (Surg ETA, Ability to Bld Prime...)

Co... E-CPR Orders

...sist
...C or Emerg
...d?

...mergency Release Bld:
Completes and SIGNS Emerg Blood Form on Top of Cart and Ensures completion of "pick up request form"

...u<15kg
4u >15kg in Cerner and Ensures completion "pick up request form"

RT
Cont to Ensure Stable Airway and Breathing and Assist with CPR

Moving Boom and Vent for ECMO pump With Bed Side RN 2

ECMO 1
Moves Pump and Battery in rm

Grabs Rapid Bag

Grabs ECMO Pump Pack from Deployment Cart

GrabsMEDS

F/U on Status of Bld w/ BB

ECMO 2
Cannula Cart to outside of rm

ECMO 2
Confirms Canula size with MD Lead

Sets Cannulas on Pump

PHASE 3 NON STERILE ECMO

RN TEAM LEADER:
Assign appropriate staff PRN
Ensures completion of all phase tasks
Maintains Situational Awareness

Recorder RN:
Con't same duties

CPR RN
CPR Rotation with Extra Staff in rm

Assigns Sterile CPR "Team"

MED RN 1
Prepares CODE meds - Stationary

MED...
Con't ...
Med...
Assistar...

...ck on one bs table

Bed Side RN 2
Opens General Pack

Gets Sterile

...D ASSIST
Assistance per MD Lead Instructions

Gets Sterile

RT
Cont to Ensure Stable Airway and Breathing and Assist with CPR

ECMO 1 ("Pump Person")
Positions and plugs in Pump

Turns on& Checks Pump

Plasmalyte Prime

CO2 Prime

Albumin Prime

Communicates w/ MD LEAD - Time for Blood?

Blood Prime

Add Meds

Zero flow sensors

Fine Tune Pump Position

ECMO 2
("Runner")

No
Add More Meds if no blood prime

Checks Bld w/ RN

Pump blood gas & ACT after adequate circulation of gas flow

Surgeon
Arrives with Loops

Assesses Situation

Gets Sterile

Surgical First Assist
Arrives with Loops

OR Scrub Tech/ RN arrives

OR Scrub Tech/ RN gets sterile

OR Circulator arrives

Circulatory Role
Circulates at direction of surgeon

PHASE 4 STERILE PHASE

RN TEAM LEADER:
INITIATES TIME OUT
Pt ID (and weight)
Cannulation Site and Size

MAINTAINS SITUATIONAL AWARENESS

Recorder RN:
Con't same duties

CPR RN
Hands off CPR to Sterile OR Team

MED RN 1
Prepares CODE meds

Bed Side RN 1
Con't Admin of Code Meds and Fent and ROC PRN

Admins Heparin prior to cannulation after confirmation with MD Lead

Bed Side RN 2
Set Up Sterile Field on 1 bed side table frm ECMO Cart

Opens Instrument Tray and places middle tray on sterile field

MD Lead
Assigns First Assist, and Scrub Role with RN Team Lead

Review Pump Labs and order additional meds prn

Confirm Cannula Size with Surgeon

Orders Admin of Heparin

MD ASSIST
Performs Sterile CPR

RT
Cont to Ensure Stable Airway and Breathing

ECMO 1
Clamps Circ

Prepares Lines for Cutting

Pass Lines Off

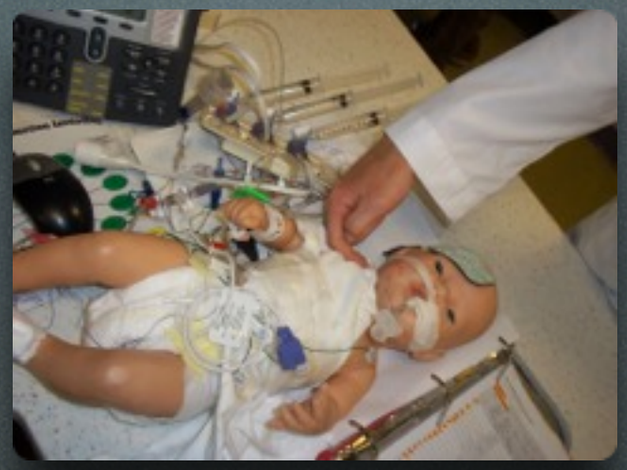
ECMO 2
Confirms with Scrub Role: Location of Cannulation

Placement of Cannulas on Sterile Field

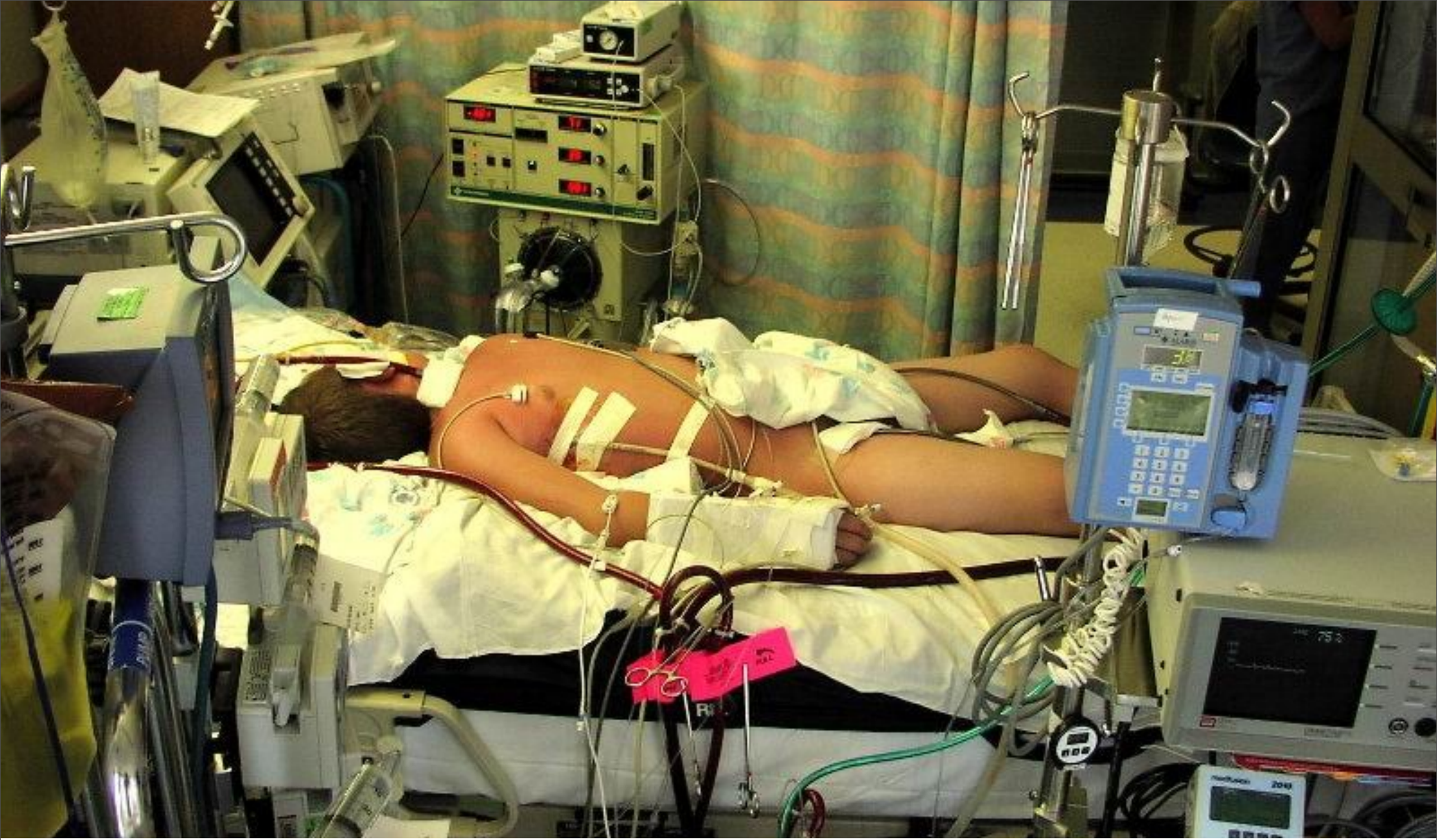
Prepares Lines for Cutting

Surgeon begins dissection and cannualation

It takes a village !



Simulation for Rapid Deployment



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Complications

- Bleeding
- Thrombosis
- Embolism-air, clots
- Mechanical- circuit, oxygenator, or pump
- Infections
- Surgical

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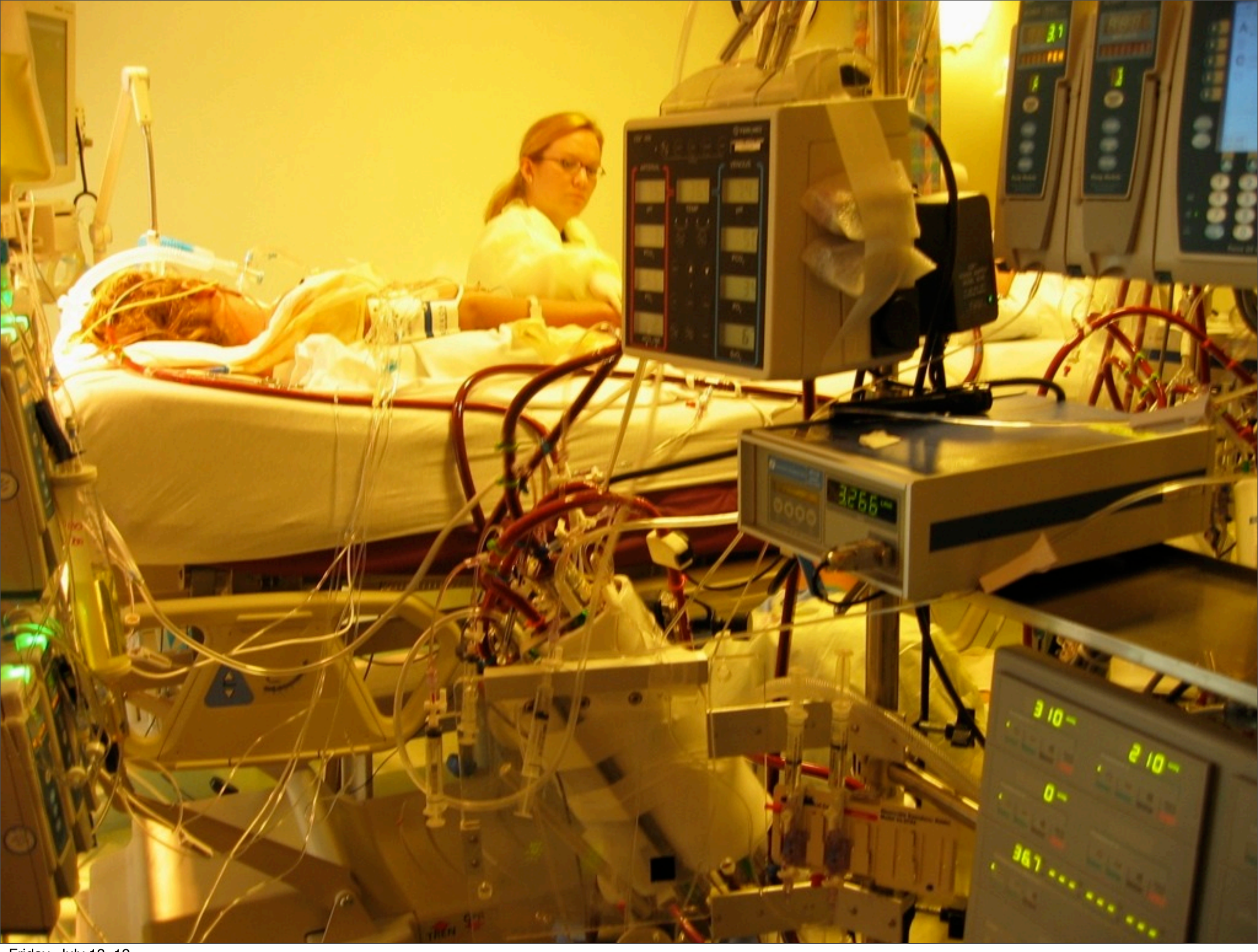

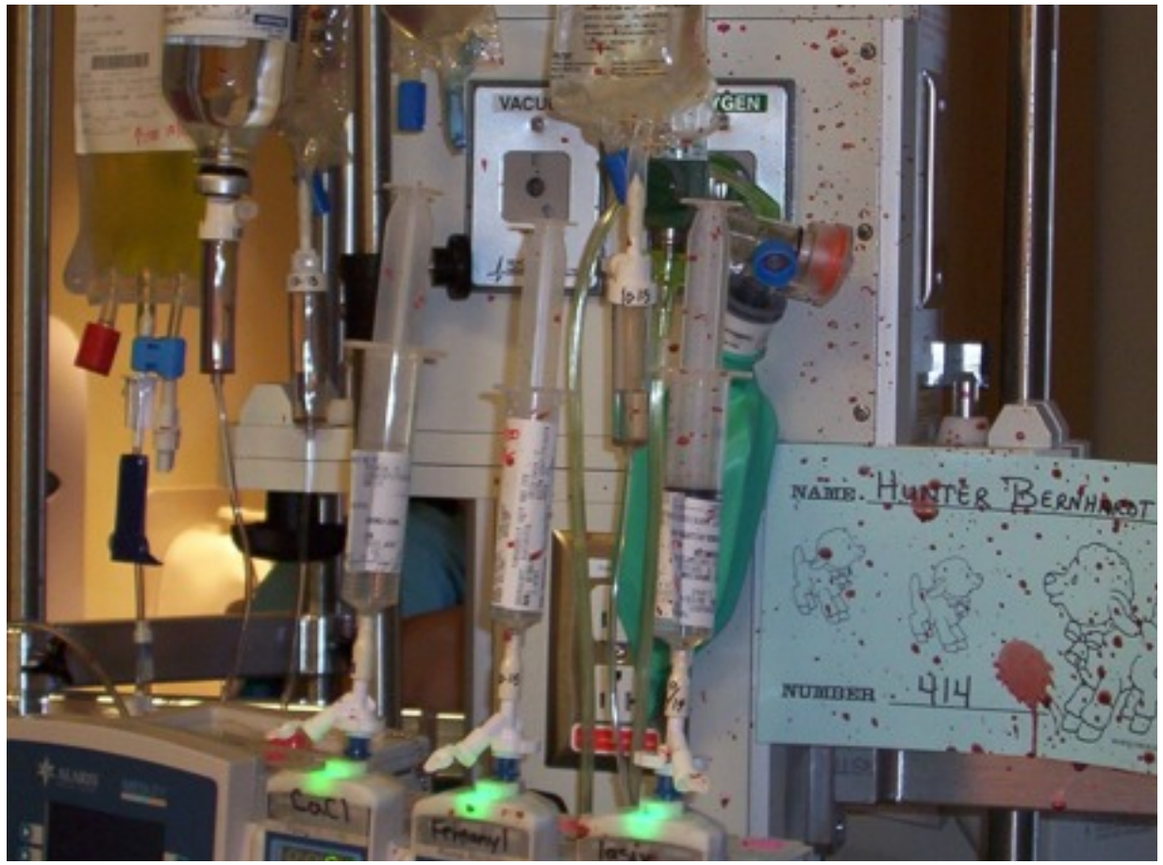

ECMO Circuit Rupture

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Future directions & novel uses of ECMO

- Pump augmented hemofiltration
- ECCO2R
- Tracheal surgery
- ECPR
- Therapeutic hypothermia
- ECMO transport
- Pumpless system
- Tidal perfusion

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got questions ?

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